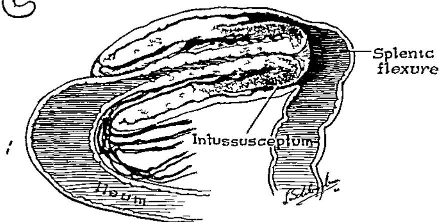
INTUSSUSCEPTION IN INFANTS AND CHILDREN

Frontispiece — The pathological changes in the acute form of invagination are chiefly of two kinds 1 Obstruction of the bowel 2 Strangulation of the intussusceptum The obstruction is due not only to the narrowing of the lumen of the bowel by the invagination but also to the swelling of the invaginated portion caused by the constriction of the blood vessels supplying the intussusception at the neck of the intussuscipiens The acuity of the symptoms is always proportionate to the severity of the strangulation at this point The circular constriction interferes with the return of venous blood from the intussusceptum which is followed by edema complete stasis and gangrene of the constricted portion An acute invagination becomes irreducible by ordinary means within a few hours on account of the appearance of edema in the intussusceptum If the strangulation is less intense the passive congestion precedes a plastic inflammation of the serous surfaces held in apposition and adhesions form which again oppose or render a reduction impossible Nicholas Senn 1893

The vast majority of intussusceptions in infants and children are of the kind shown here The intussusception begins at or near the ileo cecal valve and there is no obvious local anatomical lesion to cause it From the first moment there is simultaneous interference with the patency of the alimentary canal and with the vascular supply of the intussusceptum The drawings indicate the manner in which the mesenteric vessels are drawn between the layers of the intussusception and compressed The slight interference with lymphatic and venous drainage which occurs almost at once results in edema and an increase in the tissue pressure This further increases the resistance to the return of venous blood Venules and capillaries become enormously engorged Edema increases until there is complete obstruction to venous outflow As arterial blood continues to pump in the tissue pressure rises until it is higher than arterial pressure and gangrene ensues The drawings indicate the sharp U shaped turns of the bowel and of the mesenteric vessels at either end of the intussusceptum The outer coat of the intussusceptum is isolated between these two sharp bends and is understandably the first to become gangrenous Gangrene makes its appearance in this coat near the tip of the intussusceptum and progresses backward towards the neck of the intussusception Identical changes follow in the innermost layer of the intussusceptum The intussuscipiens is rarely damaged

Ileocolic
vess
Terminal
ileum
Ileocecal
valve
Cecum
Intussusceptum

Intussusceptum
Enlarged
Ede
ma
Blood vessels
drawn in
layers
Kinking and
compression of vessels
leads to engorgement
and edema



PEDIATRIC SURGICAL MONOGRAPH SERIES

Edited by

MARK M RAVITCH M D

Associate Professor of Surgery

The Johns Hopkins University School of Medicine

Surgeon in Chief The Baltimore City Hospitals

Baltimore Maryland

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IN INFANTS

AND CHILDREN

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To

DOCTOR EDWARDS A PARK

This book is humbly dedicated by one of the many men and women in medicine whose lives and careers he so profoundly influenced

PREFACE

The field of pediatric surgery has expanded so rapidly in recent years that there would appear to be a place for a series of monographs devoted to its various phases The body of information available is now much greater than can be satis factorily handled in the limited space afforded in a textbook Some of these monographs will deal with single conditions or diseases others of wider scope with organ systems or specialty fields within pediatric surgery

Only a very few years ago in the limited field which was then pediatric surgery intussusception occupied a prominent place It therefore seems eminently suitable that the first monograph in the series should deal with this subject of tradi tional interest in pediatric surgery

In 1933 Dr Dean D Lewis then Professor of Surgery at the Johns Hopkins University School of Medicine returned from a meeting of the American Surgical Association at which Dr E H Miller of Chicago had presented a paper on Intussusception Dr Miller had described his own results which he considered poor and re ferred to the remarkable results of Hipsley in Australia with reduction of intussusception by hydrostatic pressure Dr Lewis at a student clinic in customary fashion read to us directly from the writings of those concerned with the problem under discussion—in this instance the classical work of Clubbe—the great Australian student of intussusception I was a third year student at the time and interested in pediatric problems Reading of the work with hydrostatic pressure reduction of Clubbe and of Hipsley then of Hirschsprung and his successors in Scan dinavia I became enthusiastic about atte to try the method These attempts began in 1939 when I was a junior Assistant Resident That I was permitted to make these attempts was due the support and encouragement of Dr E A Par then directing the Harriet Lane Home for Inva lid Children and Dr Warfield M Firor directing the Department of Surgery Since 1941 these studies have profited from the warm inter est of Dr Alfred Blalock Professor of Surgery and Director of the Department of Surgery

In a hospital where from its inception the ward services have been almost wholly in the con trol of the Resident Staff I owed much to the Pediatric House Staff who were enthusiastic from the first and to my various predecessors in the surgical residency who varied from tolerance to warm cooperation but were always helpful — Doctors E S Stafford David H Sprong Jr August F Jonas Jr James M Mason III ar William G Watson

In recent years the surgical house staff has con tinued the program more or less independently and it is a pleasure to report that the clinical results have steadily improved

Dr Robert M McCune Jr while still a cal student contributed heavily to the laboratory experiments and clinical analyses upon which I have drawn freely

Intussusception as a disease has fascinated pe diatricians surgeons and pathologists in the p

those whose connection with the subject
a noteworthy are John Hunter D Arcy
Rokitansky Nothnagel Nicholas Senn
n Hutchinson Hirschsprung and Sir
Clubbe

out attempting to write a monograph so
as to repel the more general reader, we
ed to treat in systematic fashion the his
pathology and the clinical features of
ase and its therapy Because of our special
in the hydrostatic pressure reduction of
ception under fluoroscopic control we
cluded a substantial series of reproductions of films taken during such reductions It has been our observation that few pediatricians or surgeons who have had experience of the method in operation in seasoned hands have failed to be convinced of its value The numerous roentgenographic films reproduced which constitute a series of illustrated case histories will it is hoped serve as a body of clinical experience for those unacquainted with this method and as an atlas for reference to illustrate the various appearances of intussusception during the barium enema treatment

M M R

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INTUSSUSCEPTION IN INFANTS AND CHILDREN

Chapter I

MATTERS OF HISTORICAL INTEREST CONCERNING INTUSSUSCEPTION

Accustomed as we are to considering intussusception as a common disease of infancy with an easily recognized striking and pathognomonic clinical picture it comes as something of a surprise to realize that intussusception has been known and recognized probably no more than three hundred years Otto Leichtenstern who wrote extensively on intussusception in the 1870 s is authority for the statement that J C Peyer in 1677 first clearly recorded the clinical differentiation between volvulus and intussusception Barbette a few years earlier clearly described intestinal invagination

Discussions of the historical aspects of intussusception regularly state with confidence that Hippocrates advised the use of enemata and the bellows injection of air for intussusception and that Praxagoras of Cos even advised operation for the same disease A close reading of the pertinent sections of Hippocrates which are to be found in the Littré translation show that he was talking simply of ileus and that there is no suggestion or indication that he was speaking of intussusception or knew it as a specific form of ileus He did *it is quite true talk of the use of* enemas for ileus although they seemed to be oil injection enemas and not enemas of large volume He did specifically state that if these failed a bellows should be connected to the anus and the bowel inflated with air The only information we have on Praxagoras is that which has come down to us from the lost Greek writings of Soranus of Ephesus by way of the translation into Latin of Caelius Aurelianus Here there is a very long section on Acute Intestinal Obstruction which the Greeks call Ileus He states that the various terms for intestinal obstruction were given because the patient has a feeling that the folds of his intestine are tied up and twisted or because the pneuma is blocked and shut off the resulting involution of the flow producing cramps and twisting pains or else because the violent pains over the parts affected cause the patient to be bent over twisted and doubled up He goes on to discuss other designations and their etiology with their origin and meaning such as fence obstruction etc nowhere is there a suggestion of invagination or involution The symptoms described are the symptoms of mechanical intestinal obstruction but any mention of a bloody discharge from the rectum is conspicuously absent and there is no mention of any specific type of ileus peculiar to children or infants

In the Eighteenth Century Intussusception was well recognized and John Hunter s paper in 1789 described the specimen from a fatal intussusception in a nine month old child He read his paper before a small group that met monthly at Slaughter s Coffee House in St Martin s Lane and called themselves A Society for the Improvement of Medical and Chirurgical Knowledge This was a select society of twelve members selected from the staff of St Bartholomew s St George s Guy s and St Thomas s Hunter s ana

ical observations were accurate but his thera tic suggestions leave something to be desired erything that can increase the action of the stines downwards is to be particularly ded I should therefore advise giving vomits a view to invert the peristaltic motion of the aining gut which will have a tendency to ig the intestines into their natural situation

lthough intussusception was well known in Eighteenth Century it is astonishing that a ew of a considerable number of textbooks of ery and textbooks of the diseases of children ss until the second half of the Nineteenth tury almost no mention of intussusception ntussusception in the mid Nineteenth Cen was recognized as a nearly universally fatal ase Leichtenstern pointed out that the mor ty in reported cases was 88% in the first six nths of life 82% in the next six months of life 72% from two to ten years

Operative therapy was rarely undertaken sters of various types were employed but it would appear that most physicians did not carefully and consciously employ these in an effort to reduce the intussusception by hydrostatic pressure It is equally obvious that others did attempt just that knowingly Air was also frequently injected into the rectum either by a bellows or gas from a generator of one kind or another The use of a wand to repose the intestines then a standard practice as it had been for some centuries past was as ineffective as it might be expected to be More attention seems to have been paid to the construction of the wand and the character of its tip than to the hopelessness of its use A common preference in the Nineteenth Century seemed to be a whalebone bougie with a soft covering

The following letter to the Editor of the *Lancet* which appeared in the issue of March 18th 1838 under the title Intussusception in Children gives some idea of the therapeutic arguments at the time

Sir

The subject of intussusception having lately been discussed at the two principal medical societies in London and nothing new having been elicited on these discussions I take the liberty of suggesting to the profession through the medium of your valuable periodical the trial of inflating the bowels by means of a Clyster pipe attached to a common pair of bellows It has fallen to my lot to witness several of these distressing cases in children The nature of the obstruction was foretold during life and unfortunately verified by postmortem examination The last case of the kind which came under my care about two years since presented all the usual symptoms intolerable restlessness the most obstinate sickness the singularly distressed state of countenance and shrunken features The usual remedies we had recourse to viz warm baths glysters anodyne frictions over the abdomen &c but without avail As a forlorn hope I made trial of inflation by the above means with a most happy result The sickness immediately ceased the child within an hour passed a natural stool fell into a sleep and in the morning was almost without ailment

I am Sir your constant reader and obedient servant

Samuel Mitchell Surgeon
Kingston on Thames
February 26 1838

A quotation from J Lewis Smith s *A Treatise on the Diseases of Infancy and Childhood* will give a picture of the disease in 1872 just before the reports of Hutchinson and Hirschsprung

Prognosis— Intussusception is in its nature so grave an accident that the physician called to a case should always expect to predict a fatal result

Cathartic remedies act as a vis a tergo and may cause a still further descent of the inverted intestine Quicksilver was similarly condemned He then went on to state The proper treatment consists in attempts to reduce the peristalsis by pressure from below and is applied either by liquid inject ons into the rectum or which is far more preferable inflation of the lower intestine by air or gas If reduction is not effected after sufficient trial the indication is to maintain the strength of the patient and give palliative remedies in the hope that recovery may take place through the process of sloughing and adhesive inflammation

An apparatus for the production and injection of carbonic acid gas has been invented by Schultz and Warner of this city (New York) and is manufactured by them It consists essentially of two glass chambers one over the other In the lower one a bicarbonate is placed and in the upper an acid in a liquid state By the gradual admixture of the two carbonic acid is set free An elastic tube conveys the gas from the lower chamber This apparatus has been used by physicians of this city for the reduction of intussusception and other purposes and is a useful invention

The same firm and several others in this city prepare for the shops quart bottles of highly charged carbonic acid water from which when inverted a powerful current of carbonic acid gas can be obtained Two or three of these bottles with a portion of the tube from Davidson s syringe which can be readily attached to the stem from which the gas escapes constitute all that is required for an ordinary case

Whether air or carbonic acid is employed it is necessary to produce distention of the intestine to its fullest extent below the seat of the complaint without endangering rupture and of course the sooner it is out the better the chance of success

The employment of quicksilver by the rectum with the thighs elevated has been suggested to me as a dernier resort

As for operation— I apprehend that there are few surgeons at the present day who would perform or recommend this mode of treatment in a child

In the first edition of the famous *Text On the Diseases of Infancy and Childhood* by L Emmett Holt the treatment of intussusception which is advised is insufflation with the bellows and simultaneous manipulation through the abdomen If one preferred it was acceptable to employ an enema holding the reservoir four to five feet above the patient and raising it if necessary to six to eight feet operation to be performed if these failed In 225 collected cases in children with the use of air or fluid Holt pointed out there had been only one rupture of the intestine

Nicholas Senn the brilliant and many faceted surgeon of Chicago who had studied intussusception experimentally felt that gas was infinitely preferable to fluid His are the first experiments evaluating pressure reduction He employed hydrogen gas either manufactured elsewhere or manufactured on the spot in a generator with zinc chips and sulphuric acid and stored in a large rubber balloon In experiments in which intussusceptions were produced in animals and the animals then operated upon 36 hours later he states the bowel at the point of operation was very vascular and the neck of the intussuscipiens covered with plastic exudation The sutures (previously inserted to prevent spontaneous reduction) were removed and the rectum distended with gas for the purpose of effecting reduction As soon as the colon had become thoroughly distended the adhesions which had formed gave way with an audible noise and complete reduction followed in such a manner that the point last invaginated was first released As the force necessary to rupture the adhesions and reduce the bowel produced no

ury of any kind to the intestine below or at seat of invagination this experiment would d to prove that insufflation can be prac l successfully in cases of invagination of sev days duration The pressure upon the rub balloon should be uninterrupted and almost exceed two pounds to the square inch agination is effected by inflation by two inct forces In the first place the steady ic pressure of the gas distends the bowel ... the sheath and the returning cylinder ich makes traction upon the neck of the intus ipiens while the column of gas by its pres *against the apex of the intussusceptum* as a direct reduction force

Reduction was resisted after a time either *the swollen edematous intussusceptum or* by iesions of the neck of the intussuscipiens or ween the serous surfaces throughout the in ed portion of the bowel From these ervations I have come to the conclusion that tion by gentle but efficient distention of bowel below the invagination would suc in the majority of cases if this procedure practiced before either of the two princi conditions which cause irreducibility have l time to make their appearance

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The first certain laparotomy for intussuscep tion in a child was by Gerson and was reported by Hachmann of Hamburg in 1810 This was a 12 week old infant A good portion of the intussusception was reduced before gangrenous bowel suddenly delivered and tore with a fatal outcome

The next recorded operation for intussuscep *tion was successful, and was the first one in the* United States It was an operation performed by Doctor John R Wilson of Tennessee and was reported by his pupil Mr W W Thomp son to the *Transylvania Journal of Medicine and the Associated Sciences,* 1835 Volume 18 page 362 The paper is titled A Case of Introsuss ception in which an Operation was Successfully Resorted to by John R W Wilson M D of Rutherford County Tennessee in December 1831 The patient was a negro slave who had failed to respond to the customary treatment of active purgation and metallic mercury by mouth The reduction was easily effected at operation and the author concluded his recov ery was rapid and entire The success of this case in which the operation was so long deferred and at last performed under such unfavorable circumstances warrants the pro priety of resorting to it in the disease and proves that relief may occasionally be afforded by this means when all others have failed

Wilson s grandson O H Wilson Professor Emeritus of Pediatrics at Vanderbilt University School of Medicine reports the finding of Doc tor John R Wilson s day book with an entry for November 20 1831— $5.00 for operation of Gastrotomy on Chas Dements N boy with a record of several subsequent visits A laconic enough memorandum of an historic operation

There were a few other reported cases of operations for intussusceptions in adults and in infants among them unsuccessful operations in

England by Spencer Wells the renowned ovariectomist one of the founders of Gynecology and in Russia by Pirogoff the great military surgeon On November 11 1873 Jonathan Hutchinson read before the Royal Medical and Chirurgical Society his first paper on Intussusception reporting a successful operation performed in 1871 on a two year old infant referred to him by Warren Tay He stated—

Our first measure of treatment consisted in putting the child under chloroform and then whilst she was held up by the feet distending the rectum to the utmost with warm water

By this means the involuted part could be forced up into the abdomen so as to be quite out of reach of the finger and once or twice I tried to hope the reduction had been effected On each occasion however when the lower bowel was allowed to empty itself the intussuscepted part became prolapsed as before and showed clearly that we had gained nothing

It was very evident from the child s condition that unless relief were afforded she would not live long and I therefore felt justified in telling the parents that although an operation would become in itself very dangerous yet I felt that it afforded the only chance

He made a lower midline incision withdrew the six inch long intussuscepted mass reduced the intussusception without any difficulty and replaced the bowel The operation had been an extremely simple one and had not occupied more than two to three minutes

From this time on although it is obvious intussusception was still an extremely grave disease and carrying in spite of all a high mortality it was considered a disease in which the outcome could be materially affected for the better by proper treatment Theretofore recovery following rectal injection had been irregular and uncertain and operation had rarely been attempted Such survivals as did occur were due in the main either to spontaneous reduction of the intussusception or to gangrene of the intussusceptum and passage of the sloughed intussusceptum by rectum before the child had died of the consequences of intestinal obstruction In such cases the tight adhesion of the intussusceptum and the intussuscipiens at the neck of the intussusception maintained the continuity of the bowel although there frequently resulted as a secondary manifestation either chronic intestinal obstruction from cicatricial stenosis or secondary perforation through the poorly healed area with peritonitis and death This is best described by Leichtenstern— Numerous trustworthy observations show that separation of the intussusceptum may lead to complete cure of the invagination But this mode of termination has many changes which threaten life The separation may take place too early before there is solid union at the neck of the invagination Perforation or rather rupture is the result or a part of the intussusceptum remains and causes a new invagination by increase of what is left in the old one In other cases constriction of the intestine takes place at the inactive line of separation increases more and more and often causes death after some years Finally torpid ulcers of the mucus membrane may remain at the place of separation and cause perforation long afterwards or defective nutrition as a result of diarrhoea Among the rarer illustrations we find death by septicemia —thromboses—metastatic abscesses in the liver—perforation and formation of a fecal cloaca

It is one of the ironies of medical progress that just at the time that Hutchinson was demonstrating the feasibility of operative reduction of intussusception in infants Hirschsprung of Copenhagen discouraged by the high mortality of intussusception instituted a plan of controlled hydrostatic pressure reduction of intussusception

Hirschsprung s first report was in 1876 By 1905 Hirschsprung was able to report on 107 personal cases of intussusception His results were so superior to those previously reported that his contemporaries doubted his conclusions He was forced in self defense to publish a paper reporting each of his 107 cases He presented a 35% mortality in a disease which up

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Fig 1 (a) There must of course arise a certain number of cases in which the early diagnosis is difficult For such cases I believe that the x ray with bismuth injections may be very useful During the last few months I have employed this method three times twice to see if I could facilitate the operation by causing partial reduction with enema and once for diagnostic purposes Plate I was taken of an infant six months old who was brought to the hospital about 24 hours after the onset of symptoms. These consisted of intermittent attacks of abdominal pain followed by vomiting and bloody stools, with very little feces. The abdomen was not distended and the mass could be very easily felt in the mid line just above the umbilicus The diagnosis was of course simple but I had a bismuth injection given in hopes of causing partial reduction and thus facilitating the operation This end was not accomplished The position of the tumor remained unchanged but the plate shows very clearly how useful this procedure might be in a case where the diagnosis was difficult Note the cervix like shape of the advancing part of the intussusception and how distinctly this is shown to be within the bowel by the bismuth clinging to the wall of the intussuscipiens extending back over it (W. E. Ladd Boston Med & Surg J 1913)

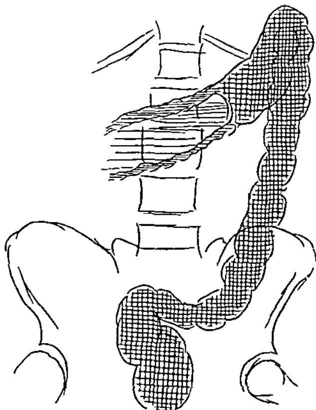
Aus der chirurgischen Universitatsklinik Rostock

Ein Fall von Invaginatio ileocoecalis im Rontgenbilde

Von

Dr C Lehmann in Rostock

Im folgenden will ich kurz uber eine Beobachtung von Invagination im Rontgenbilde berichten, die wir im November 1911, unmittelbar nach der Veroffentlichung von Haenisch über seine Methode des Wismuteinlaufs auf dem Trochoskop (Münch med Wochenschr 45, 1911) machten Leider ist die Platte verungluckt, so daß ich den Befund nur in einer Skizze wieder geben kann Mir sind bisher entsprechende Falle aus der Literatur nicht bekannt geworden, nach mundlicher Mitteilung hat Haenisch selbst einen ahnlichen gesehen



Es handelt sich um einen 18jahrigen Jungling, der seit drei Wochen an kolikartigen Schmerzen litt, Stuhl war abwechselnd angehalten und durchfällig und enthielt haufig Blut Bei der Aufnahme am 18 November 1911 fand sich ein wurstförmiger Tumor im Epigastrium der der Palpation nach dem Querkolon angehorte Die Differentialdiagnose lautete auf Tumor oder Invagination, resp beides

Bei der Röntgenuntersuchung, die genau nach den Vorschriften von Haenisch ausgefuhrt wurde, füllte sich rasch das Rektum, die Flexur und das Deszendens man sah die Wismutsaule die zunachst noch keine Haustrenzeichnung zeigte an der Flexur umbiegen und ins Querkolon fort schreiten nach einer kurzen Strecke machte sie halt, und das gefullte Ende des Querkolons blahte sich machtig auf Es fiel uns auf, daß die Wismutsäule an der Stelle wo sie das Hindernis fand, vollständig glatt abgeschnitten erschien und sich nicht etwa zapfenförmig zuspitzte, wie man das wohl bei einem stenosierenden Karzinom hatte erwarten konnen

Es wurde nunmehr eine Aufnahme gemacht, die bei genauer Betrachtung noch etwas mehr zeigte, als das Schirmbild (vgl Skizze), auch hier war die Wismutsäule plötzlich scharf abgebrochen — ubrigens war inzwischen die Haustrenzeichnung hervorgetreten —, von den äußersten Ecken der Unterbrechungslinie aber setzten sich zwei schmale 0 5—1 cm breite

Fig 1 (b) Lehmann's report in 1914 of the use of bismuth enemas in diagnosing intussusception He described the radiologic picture clearly apologizing for the fact that the plate was poor and the sketch had to be substituted for it in publication The observation had been made three years earlier in 1911 The patient was an 18 year old boy with a three week history and a palpable tumor Lehmann was apparently satisfied to have made the diagnosis. There is no mention of a therapeutic effort with the enema The intussusception was successfully reduced at operation

to that time was fatal in over 80% of the cases In 81 patients treated by Hirschsprung with enema alone, the mortality was 23% These figures compare favorably with those from The Johns Hopkins Hospital in the period from 1929 to 1938 more than 35 years later Interest in the hydrostatic pressure reduction of intussusception has been maintained in Scandinavia ever since with from time to time, attempts to add transabdominal manipulation to it In Australia, largely due to the influence of Hipsley hydrostatic pressure has been used with spectacular results

The use of the x ray in the diagnosis of intussusception was first suggested by Ladd in 1913 and by Lehman in 1911 Ladd stated— There must of course arise a certain number of cases in which the early diagnosis is difficult For such cases I believe that the x ray with bismuth injections may be very useful During the last few months I have employed this method three times twice to see if I could facilitate the operation by causing partial reduction with enema and once for diagnostic purposes (Fig 1 A) Ladd was convinced that this was a good diagnostic device and a useless therapeutic one This was despite the fact that the improved mortality which he reported in this paper from the Children s Hospital in Boston was still 15% —higher than in Hirschsprung s series reported in the previous decade Ladd himself ascribed priority of the use of the Roentgenogram in the diagnosis of intussusception to Lehman although Ladd s publication appeared earlier Lehman does state that he was reporting an observation made three years earlier when bismuth enemas were first described by Haenisch Lehman apologizes for the fact that his plate was so poor that a sketch (Fig 1B) had to be substituted for it in this publication The result however is that Dr Ladd s report contains the first published photograph of the roentgenologic pictures of intussusception

The use of the contrast enema to provide visual control of hydrostatic pressure reduction was a natural consequence of the introduction of x rays and this was reported simultaneously by Pouliquen in France Olsson and Pallin in Scandinavia and by Retan and by Stephens in this country

The first successful resection of an intussusception in a child was that reported by Clubbe of Australia, in 1897 the second by Collinson of London ten years later

The first successful resection of an intussusception in this country was reported by Peterson in 1908 Actually in the 21 years between 1896 and 1920 Clubbe could find only 15 reported instances of successful resection of intussusception in infants and it can well be assumed that very few successes had escaped report One of the brilliant early successes was that of Dowd who in 1912 reported resection of terminal ileum and right colon in a five day old baby

As it has a habit of doing in such matters time has affected the pertinency of most of the arguments for or against primary operative or primary hydrostatic pressure reduction The evidence is overwhelming that from 1877 to 1915 the results in clinics employing hydrostatic pressure reduction were substantially superior to those obtained in the clinics employing operative reduction primarily This was easily measured in terms of operative mortality In the last decade, in the clinics with the greatest interest in surgical diseases of children deaths from intussusception have been limited essentially to those children hopelessly moribund at the time of admission irrespective of whether treatment was by operation or by hydrostatic pressure reduction The argument is now based on subtler criteria which are discussed in detail in a later chapter

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Chapter II

THE CLINICAL PICTURE OF INTUSSUSCEPTION

THE INTUSSUSCEPTION

The muscles of the bowel wall are strong
And by their strength they force the food along
In rhythmic waves contractions come and go
Making the intestinal contents flow
If through any kind of morbid state
A bit of bowel wall invaginate
The muscle wall may force it on and on
Until far down the lumen it has gone
The gut below dilates for its reception
And thus you get what's called intussusception

The process starts from undue stimulation
Induced by some slight cause of irritation
A swollen Peyer's patch, a small lipoma
A Meckel's process or a papilloma
Or just a piece of solid food in gut
Where never before such food had never been put
This statement to the striking fact gives meaning
—Most intussusceptions come at time of weaning

Behold a year old bouncy baby boy
His father's pride, his mother's constant joy
In restful sleep—quite healthy it would seem—
When suddenly he wakes up with a scream
His pink face pales, his pupils may dilate
He draws his legs up, for the pain is great
But in a while the spasm seems to cease
And once again he may have sleep in peace
Yet not for long for soon he wakes again
The pain and screams recur and he may strain
And pass some blood stained mucus on his nappy
This renders both his parents most unhappy
And so they call the doctor to their aid
Of something serious they are now afraid

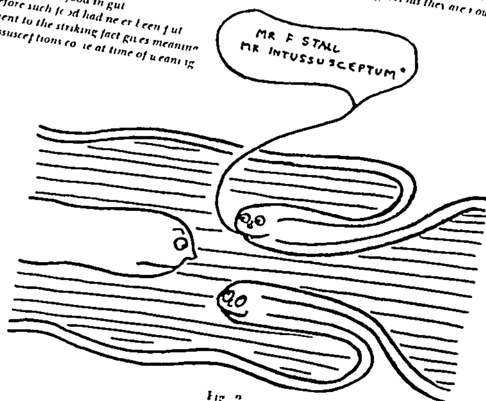


Fig. 2

The doctor with his gentle nice warm hands
Palpates the belly as the case demands
The R.I.F feels empty (Signe de Dance)
But higher up his search reveals perchance
A swelling rather sausage like which oft
Gets sometimes harder sometimes lax and soft
It may be felt in epigastrium
Or one or other hypochondrium
Or sometimes it may very slowly slide
Low down towards the pelvis on left side
Then may a finger in the rectum put
Feel the soft apex of advancing gut
And on the withdrawn finger will be found
Some blood and mucus smeared all around

Sometimes the doctor will be horrified
To see a fleshy mess protrude outside
And then the long soft swelling may perhaps
Be easily mistaken for prolapse
But if you put your finger in the rectum
It goes twixt wall and intussusceptum
But not with prolapse—for there is a septum

The colon as you know a common site is
For inflammation—here known as colitis
Which may from time to time cause doubt I fear
For blood and mucus may in stools appear
But usually the pain s not so severe
And since the motions will show faecal stuff
These points distinctive should be quite enough
(Though colon inflammation oft may render
The whole course of the colon to be tender)

Not long ago the doctor when in doubt
Would give an anaesthetic to find out
If there were any tumour on palpation—
If so then that was clearly confirmation
But in these days there is a better way
Which may the need for anaesthetic stay
For if an enema of barium
Be flowed into the bowel per anum
And then observed minutely by x rays
As it ascends the colon s winding ways
One then can see if there s invagination
And not depend upon imagination
This means a radiologist
Should often be consulted to assist

From ZETA *The Acute Abdomen in Rhyme*
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The classical case of intussusception occurs in the well nourished male child eight months old who is awakened from sleep with what appears to be violent abdominal pain flexes his thighs cries out vomits and passes a normal stool Thereafter he vomits repeatedly has obvious bouts of recurrent peristaltic pain and begins to pass bloody mucus per rectum Before long he becomes apathetic pale and soon presents evidence of dehydration The intestinal obstruction which has existed from the first moment does not become manifest for many hours The condition is fatal in three to five days if not interrupted The intussusception begins at or near the ileo caecal valve Examination of the bowel shows no obvious local anatomical cause for the intussusception

This is the classical picture and so typical that the diagnosis may frequently be made over the telephone and is commonly made by the dispensary nurse on the patient s arrival in the Accident Room or Outpatient Department However the variations of the picture are of some interest and are of great importance in permitting the diagnosis of the atypical cases which are the only ones in whom a fatal issue is at all likely today

INCIDENCE

Intussusception seems to be appreciably more common in some parts of the world than in others At the Johns Hopkins Hospital where at the Harriet Lane Home there is an extremely active Outpatient Department and where we have long had a special interest in intussusception we see no more than six to eight cases a year It does not appear that other clinics in this country see appreciably more At the Denver Children s Hospital (Packard and Allen) there were 55 cases in ten years At the Children s Hospital in Los Angeles (Snyder Kraus and Chaffin) 143 cases in ten years At the Charity Hospital in New Orleans (Kahle) 54 cases in eleven years in Milwaukee at the Children s Hospital (Thatcher) 60 cases 1917 1953 The Children s H o s p i t a l in Boston (Gross) where there is exceptional clinical experience in all fields of pediatric surgery saw 258 cases in the thirteen years 1934 to 1947 not quite twenty per year The Children s Hospital in Cincinnati (King) reports 12 cases 1947 1952 Babies Hospital in New York (San

tulli and Ferrer), 41 cases 1949-1954 both about eight cases per year The Children's Memorial Hospital in Chicago (Fox) had 90 cases 1945-1956 only ten per year and the St Louis Children's Hospital (Thurston Holowach and McCoy) 116 cases in the seventeen years 1934-1951 or again only seven per year In contrast with this American experience one unit of the Royal Hospital for Sick Children in Glasgow (Dennison) in the ten years between 1937 and 1946 admitted 237 cases of intussusception—23 to 24 cases per year From 1946 to 1956 Dennison has had the great total of 399 cases almost 40 each year! Helmer's material from the University of Lund covers 162 cases seen in three years 54 cases per year Nordentoft of Copenhagen collected 440 cases of intussusception between 1928 and 1935 63 cases per year

There have apparently been very few precise statistical studies of the incidence of intussusception In the absence of such comparable statistics one should perhaps have some reservation in asserting that intussusception is a good deal more common in Britain and in Scandinavia than in the United States MacMahon has made a unique study of intussusception in the city of Birmingham England using a biostatistical approach In the entire city of Birmingham he found for the ten year period 1945 to 1954 296 confirmed cases of intussusception in children under the age of ten years an incidence of 1 49 per 1 000 live births Spence and Court for the five year period 1944 to 1949 in Newcastle-on-Tyne found 127 cases an incidence of 3 8 per 1 000 live births In both studies in the later years of study it was found that the number of cases located was appreciably higher possibly the result of improved ascertainment

Sex

In our analysis of 152 cases at the Johns Hopkins Hospital 62% of the intussusceptions were in male children and 38% in female children This figure agrees closely with the figures of 64 2% male for Birmingham (MacMahon) 68% in London (Perrin and Lindsay) 64 1% in Sydney Australia (Hipsley) 60% in Los Angeles (Snyder *et al*) The ratio of three to two seems to be fairly constant although in our next 47 cases 1952-1958 the incidence has been 22 males and 25 females presumably a temporary statistical aberration which further experience will correct No satisfactory explanation has been offered for this male preponderance MacMahon offers an interesting analysis of the sex ratio at different ages Below the age of nine months males are only slightly in excess of females 55 4% after nine months, the excess is very marked 77 7% He found the difference in sex ratio between these two periods to be 22 3 plus or minus 5 6 which was significant

Race

In our original material 63 1% were in white children and 36 9% were in negro children Since the proportion of negro to white dispensary visits was 60 to 40 it suggested that intussusception is somewhat more common in white than in negro children In our next 47 cases 17 were white and 30 negro reflecting the change in dispensary population At the Charity Hospital in New Orleans Kahle reports the racial incidence to be proportional to the hospital admission rate

Age

As seen in Figure 3 intussusception occurs largely in the first year of life and in that year most commonly in the period from the fifth to the ninth month Of our total of 199 cases 57% occurred in children who were four to eleven months of age This is below the figure of MacMahon who found that in Birmingham 65 2% of the patients were under one year of age

Dennison reported from the Royal Hospital for Sick Children in Glasgow 73% of 172 cases under a year of age This lower age incidence is characteristic of reports from purely pediatric hospitals In our material the peak of incidence appeared to be in the seventh and eighth

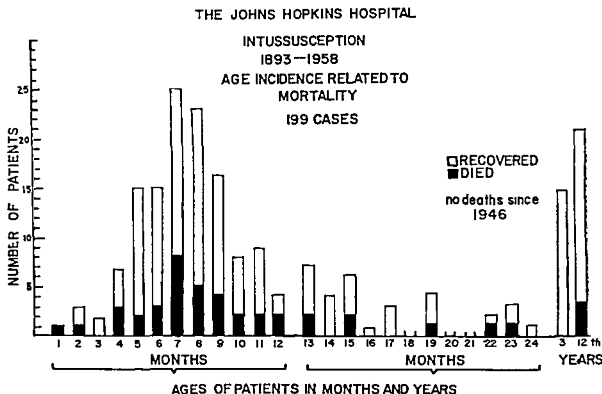


Fig 3 The peak of the incidence is in the fifth to ninth month age period and 59% of the intussusceptions occurred in children from four to eleven months of age Over 80% of the children were under two years of age In the days when deaths occurred the mortality was high in the youngest infants

months This is somewhat later than the incidence in MacMahon s series which was highest in the period through the sixth month Dennison found 102 cases under six months of age and 70 cases between six and twelve months of age Again a somewhat earlier age incidence by months than our own A number of other reports Perrin and Lindsay Hipsley show the peak of incidence at five or six months

Intussusception in the newborn infant is of special interest Rachelson reviewed almost six thousand reported cases of intussusception in the literature and found that three tenths percent had occurred in the first month of life In the past 150 years 28 cases were reported in the first month of life 18 of them in the first week of life Most of the babies were mature full term infants in good vigor The symptoms were in no wise unusual

Intussusception has been quite clearly shown to occur in utero and to be a cause of intestinal atresia The reason for the development of the intussusception in the fetus is unknown but the resulting gangrene produces destruction of the bowel and a fibrosis which gives the appearance of a congenital failure of formation of a segment of bowel However in the distal segment of bowel in such cases the end of the intussusceptum can at times be found and the presence of lanugal hairs and squamous cells of the vernix caseosa in the distal segment all indicate that the bowel had at one time been patent

Season of Year

Some writers have noticed a seasonal variation in the incidence of intussusception usually finding the incidence maximal in the summer months and attributing this to the greater frequency of gastro enteritis in such seasons As seen in Figure 4 in our material there appears to be a sustained peak from March through August and another in December through January conceivably reflecting the periods of enteritis and of

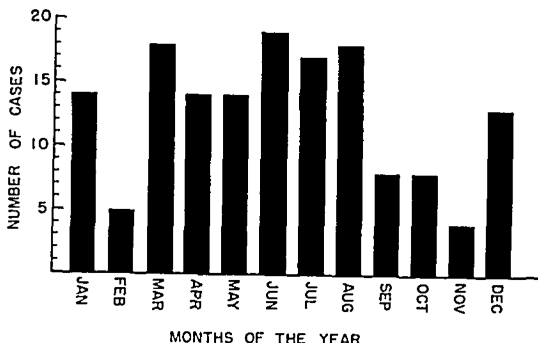


Fig 1 There is an apparent sustained peak March through August and another in December through January conceivably reflecting the maximal incidence of enteritis and of respiratory infections. (From Ravitch and McCune *J Pediat 37* 1950)

upper respiratory infections As noted the maximal incidence of intussusception is in the seventh and eighth months of life in our material This seasonal variation in the incidence of intussusception does not merely reflect a corresponding peak in the local birth rate seven to eight months previous since the number of live births in Baltimore from month to month year in and year out varies by no more than plus or minus 6% *Bolling found intussusception most common* in the summer months Close confirms this finding for younger children but found in his material that after one year of age the condition was most common in the months of December through March Fitzwilliams found a high incidence in March and December and Perrin and Lindsay report peaks of incidence in April and January but Hogg and Donovan and Hipsley found little or no seasonal variation MacMahon found no evidence of seasonal variation in his study of the total incidence of intussusception in the city of Birmingham

Birth Rank

We have previously noted that a surprising number of our patients occupied *the higher* birth ranks in their families although on the contrary Wakely and Atkinson and Hogg and Donovan found a high percentage of patients who were first born MacMahon studied his intussusception series and a comparison sample with respect to birth rank and to maternal age *and found no significant differences*

There is no evidence that there is any increased likelihood of intussusception in a sibling once one child of the family has been affected This of course does not include the instances of intussusception occurring in the occasional family with inherited multiple polyps in the small bowel

Nutrition and Previous Health

Intussusception tends to select sturdy well nourished infants The tendency for good nutrition is so outstanding that Hirschsprung

could say— Ich errinere mich auch nicht jemals bei einem atrophischen Kind eine invagination gesehen zu haben Of 119 of our 152 cases in which notation was made of the state of nutrition in 98 it was said to be good in eleven fair and in ten poor Illingsworth and Dick offer the somewhat hypothetical suggestion that in vigorous male infants with strong musculature the tone of the bowel muscle is greater than its ability to relax the motor mechanism develops before the inhibitory one and in early infancy the parasympathetic nerves are relatively weak

With respect to previous health in 119 out of 189 cases in which the histories were adequate it was found that previous health had always been good In 23 cases diarrhoea had been noted previously in 13 cases constipation had been a prominent feature and in ten cases there had been symptoms of intussusception on previous occasions Search of the history for common predisposing causes was not particularly fruitful There were 23 children who appeared to have definite bouts of diarrhoea before a sudden change in the character of the symptoms indicated the onset of intussusception Four children had received cathartics for constipation just before the onset of symptoms and three others had been severely constipated A good many of our children had upper respiratory infections Of the last 47 7 had severe upper respiratory infections However Dennison states— On comparing notes with our medical colleagues we found no relationship between intussusception and seasonal diarrhoea but an almost constant relationship with upper respiratory infections As non specific mesenteric adenitis usually follows upper respiratory infections and mesenteric adenitis is common in intussusception it is reasonable to assume that the lymphoid hyperplasia involves Peyer s patches and the collar of lymphoid tissue which is so marked in the terminal ileum of infants

It is frequently stated that the high incidence of intussusception in some European countries is associated with the fact that children there are more frequently breast fed and that the subsequent change from breast milk to cow s milk plays a part in the occurrence of intussusception The possibility that this is a factor or that the change from milk to a more solid diet alters peristalsis so as to initiate an intussusception can be no more than guessed at

Previous Attacks, Spontaneous Reduction

It may well be worth emphasizing the fact that of our first 152 patients ten had histories which clearly indicated previous attacks of intussusception with spontaneous recovery This is not often commented upon in reports on intussusception and we were unprepared for this finding The intervals between previous attacks and the intussusception which finally brought the patients to the hospital varied from ten days to six months

It is significant that nine of these ten children were operated upon (most of these cases were earlier in the series) and of these nine in three polyps were found and removed It is probable that an operative search for polyps should be made whenever there is a strong history of previous attacks One of the few discussions of spontaneous reduction of acute intussusception in children is that of Goldman and Ellman in 1940 They presented five cases of intussusception four in children much older than the usual group in whom they felt there was good evidence of spontaneous reduction of one or several attacks of intussusception Three of these children were operated upon and found to have no inciting cause such as tumor or Meckel s diverticulum Actually in one instance the history was of two weeks duration with intermittent attacks of pain and another was of one week s duration While these two cases and very possibly a third of Goldman and Ellman s five cases represent chronic non strangulating intussusception rather than repeated recurrences certainly every surgeon has had the experience of operating for an obvious intussusception only to find that it had reduced spontaneously some

time between the last examination of the abdomen and the opening of the peritoneal cavity

Kahle found five instances of spontaneous and complete reduction of intussusception in 71 cases Thurston *et al*, list 15 patients with the clinical diagnosis of intussusception eight of whom were not operated upon because of apparent spontaneous reduction or inadvertent reduction by diagnostic barium enema In an additional seven patients operation confirmed spontaneous reduction It is not stated how many of these patients with spontaneous reduction had had diagnostic barium enemas and this may merely represent a testimonial to the ease with which some intussusceptions are reduced by barium enema The same report presents one additional case of well documented spontaneous reduction of an intussusception Jones from Newcastle on Tyne reported six spontaneous reductions in 103 cases MacFarlane and Thomas cite four cases of recurrence of intussusception after operative reduction and during the same hospital admission

Santulli reports a 5% over all incidence of recurrence since 1923 In his 41 most recent cases there were four recurrences one a month after barium enema reduction confirmed at operation another five months after barium enema reduction confirmed at operation and another 24 hours after barium enema alone The fourth recurrence was four months after primary operative reduction Fox reports a recurrence rate of 1% in 90 intussusceptions operated upon at the Children s Memorial Hospital in Chicago exclusive of one child with multiple polyps who required four operations Court and Jones report that in 16 of their 121 children all operated upon primarily an incidence of almost 1[illegible]% recurrences occurred In one of these children recurrences occurred on five occasions in one on three occasions in two on two occasions and in the rest on one occasion

Spontaneous Sloughing of the Intussusceptum

From the earliest days it has been known that in some instances the intussusception becomes gangrenous and sloughs the bowel fusing at the neck of the intussusception and retaining its continuity The intussusceptum is passed by rectum and recovery ensues At times such recovery is permanent but in some instances late perforation occurs in the line of fusion of the proximal and distal intestine and in other instances a progressive cicatricial constriction occurs at this spontaneous anastomosis producing intestinal obstruction once more Today such instances of sloughing of the intussusception are only rarely seen and under conditions of gross neglect and misdiagnosis or in the absence of medical care In earlier days such a spontaneous passage of a gangrenous and separated intussusception was the patient s only hope and as late as 1906 Harvey Cushing recorded in the history of a child with an intussusception that operation was postponed in the hope that sphacelation might take place and the sphacelus be passed entire per rectum In contrast to the rarity of such cases today Leichtenstern in 1894 reported 42 collected cases of spontaneous resolution of intussusception by sloughing The bowel sloughed in periods varying from 11 to 21 days after the onset of the intussusception and the separation was usually ileal Such instances were rare in infants and occurred chiefly in older children Treves described the mechanism of the slough setting out to explain the observation that at times the slough was passed with the mucosa side out and at times with the mucosa side in He concluded that if the innermost loop of bowel separates first the intussusceptum will completely evert itself within the bowel so that it will be mucosa out and serosa in and when finally the returning layer of the intussusceptum separates the segment is passed essentially inside out If the returning loop separates first at the neck of the intussusception it is passed down over the entering loop until the entire intussusceptum lies extended in the bowel serosal side out and passes when the entering loop separates at the neck

A remarkable case is reported by Rachelson

of a newborn infant which at the age of 30 hours passed an eight centimeter length of gangrenous bowel mucosal side out The child became obstructed and a lipiodol enema showed a typical intussusception at the mid transverse colon which was reduced to the terminal ileum where complete obstruction to the further flow of contrast material occurred Operation was undertaken when the baby was 56 hours old Incredibly the ileum was found completely divided and both ends sealed off The only possible explanation is that this was a gangrenous intussusception part of which had sloughed and that the lipiodol had reduced so much of the intussusception as remained allowing the two ends of the bowel to separate and that in a newborn these ends were able to seal off for the 24 hours between the lipiodol enema and the operation

SYMPTOMS

The chief complaint in 44% of our cases was vomiting and in 42 8% of the cases was the passage of blood per rectum The patients being largely infants only 25 7% of the mothers considered abdominal pain the chief complaint In some instances pain and vomiting or pain and bleeding or vomiting and bleeding formed joint chief complaints In the remainder of the cases prolapse of the intussusception distention constipation diarrhoea fever prostration and many other symptoms were variously given as the chief complaints The symptoms of onset tend to differ somewhat from the presenting symptoms at the time the infants are seen As seen in Fig 5 evidence of abdominal pain announced the onset of intussusception a little more frequently than did vomiting 98 out of 199 or 49% as compared to 66 out of 199 or 31% The appearance of blood per rectum was the first symptom in only 23 out of 199 or 12% As might be expected pain is increasingly the first symptom in successively older age groups while blood in the stool is the first recognized symptom almost solely in infants in the first two years of life when the less dramatic symptoms may not command the mother s attention

SYMPTOMS OF ONSET
199 Cases of Intussusception

	0 Two (Yrs of Age)	*Two & Over (Yrs of Age)*	*Entire Group*
Pain	69/161—43%	29/38—76%	98/199—49%
Vomiting	63/161—39%	3/38— 8%	66/199—31%
Blood	20/161—12%	3/38— 8%	23/199—12%
Refusal to eat	8/161— 5%	1/38— 3%	9/199— 4 5%

Prolapse restlessness diarrhoea constipation distention nausea listlessness fever and convulsions were the first symptoms recognized in the remainder of the cases

Fig 5 Pain is the commonest symptom at the onset of intussusception vomiting next and bloody rectal discharge third In the infants pain was not appreciated by the parents as frequently as in the more articulate older children

Pain

A history of apparent pain at some point in the course of the disease was obtained in 60 7% of infants under one year of age and in 81 8% of the infants one to two years of age and 91 3% of the children over two years of age This presumably reflects equally on the articulateness of the patients and the perceptiveness of the mothers Gross and Ware report that rhythmic pain was observed in more than 95% of their cases Kahle states that pain was present in every patient and was the first symptom in all but two of his series Nordentoft noted pain at some *time in 98% of his cases and again the only* patients in which no pain is reported to have occurred were the youngest infants

Vomiting

In all 92 8% of the children vomited before treatment was begun In the patients under the age of two years vomiting occurred at some time in 91 6% In the children two years of age and over 82 6% vomited As to the relationship of vomiting to the time of onset of symptoms it is found that 73% of the infants under two years of age who vomited began to vomit in the first three hours of the disease while in the children over two 52% vomited in the first three hours It would appear then that vomiting occurs most uniformly in the younger infants and in these infants vomiting tends to be earlier in the

course of the disease. This early vomiting is of course reflex vomiting. The vomiting of intestinal obstruction is a late sign which should never been seen in an intussusception which has been properly handled.

The feeding history of the children after the onset of symptoms is of interest. Only nine of 112 in whom data are available took food and retained it, but 47 out of 112 took food when it was offered after the onset of symptoms, although they proved to be unable to retain it.

Blood

In all, blood was seen in 91%. In 95% of the patients *under two years of age, blood had been* observed in stools or in the rectum, but in only 65% of the patients over two years old. In all, 59% of those who showed blood at all ages showed blood in the first 12 hours and 37% of those showed blood in the first three hours. There appears to be little difference in the appearance time of blood in the stool in the two age groups, but the younger children are more likely *to show blood than are the older ones.* The blood was prominently mixed with mucus in the majority of the cases. At times the passage *consisted almost entirely of mucus which* was produced with only a slight admixture of blood and occasionally with blood detectable only under the microscope. In some instances the passage was a thin mahogany colored fluid. A few white blood cells were not uncommonly *seen in the stool, but it was uncommon to see* actual pus. In many cases blood was detected only on the examining finger, further emphasizing the necessity for rectal examination. In Thatcher's series blood was found in 61% of the patients, in Cross's series in 8[illegible]%, *in Thurs*ton's in 80%, and in Kahle's *in 90%.* *Norden*toft found passage of blood from the bowel in 88% of the patients under two years of age and in 98% of those above that age.

Constipation

In 13 of the 1[illegible]2 cases, *constipation* was noted as a complaint more commonly in the less articulate, younger patients. The absence of stools after the onset of symptoms is a negative symptom of some importance, although it is not uncommon for the patient to evacuate his bowel shortly after the onset of intussusception.

Diarrhoea

Diarrhoea after the probable onset of intussusception occurred in 13, or 6.5% of the 199 cases. Eleven of these thirteen patients were under one year of age. This symptom may occur when obstruction to the bowel is still incomplete. Two of these 11 patients did not have a palpable mass on physical examination. Diarrhoea occurs in intussusception with sufficient frequency *to make it wise to consider the diag*nosis of intussusception in infants presenting an atypical clinical picture of dysentery. Of these 13 patients, six were actually first mistakenly diagnosed as having dysentery and three died as a result of the ensuing delay.

Prolapse of the intussusception through the anus occurred in seven children, an incidence of 3.5%, with no apparent predilection for any one age. Cross and Ware found six cases of prolapse of the intussusception outside of the anus in their series of *610.* In *Kahle's 1951 report of 54* cases, prolapse of the intussusception through *the anus had occurred in two.*

Distention as a *complaint was rare, being* made only three *times in all, each time in an infant.* Listlessness, drowsiness, prostration were noted by all mothers in 30% of all cases with no variation in distribution in the age groups. Only one mother had felt a mass in her child's abdomen.

EXAMINATION

Fever

There were 97 children under one year of age in whom there were data on the tempera*ture and of these 11 out of 97, or 12%, had a temperature of 101°F. or above at the time of* admission. *28 out of 97, or 29%, had tempera*tures of 102° F. or over and 12 out of 97, or 12%, 103° F. or over. In the one to two year age group *six out of 19, or 32%,* with data had temperatures of 101° F. or over, and in the group over two years

of age three out of 21 or 14% had a fever of 101°F or over

Fever is both commoner and higher in the younger patients

There were 35 fatal cases (all fatal cases were prior to 1946) in which the admission temperature was recorded There were 15 children who had temperatures of 103°F or over on admission and 11 of these 15 73% died There were four who had a temperature of 104°F and these four all died Of the fatal cases 23 out of 35 or 66% of the patients had a temperature of 101°F or over Thus the presence of high fever was of very grave prognostic significance although in a third of the fatal cases in which there were data the patients had temperatures below 101°F

In the records of the patients before the reduction of the intussusception pulse and respirations are not regularly noted and no statistical studies could be made In both features the trend is toward elevation

White Blood Cell Count

Of the 109 cases in which the white blood cell count is recorded before treatment the count was 12 000 or over in 60% and 13 000 or over in 53% In 17% the white blood cell count was 20 000 or over

Of the patients who died the leucocyte count before traatment is recorded in 21 Of these 14 out of 21 or 67% had counts of 12 000 or higher but since 51 out of 88 or 50% of the survivors with data on white blood cell count had counts of 12 000 or over leucocytosis is of no prognostic significance

Prostration

Many of the prostrated children were cold and sweaty some unresponsive all of them torpid apathetic knocked out

Of the total of 199 cases in our earlier report the history permitted evaluation of this symptom in 137 Of this group 66 or 137 or 48% presented the appearance of prostration Of the 76 showing little or no evidence of prostration nine died Of the 66 noted to be prostrated 28 or 42% died In six of the fatal cases data was lacking as to prostration Obviously the signs of torpor and depression are indicative of graver progression of the disease There is no important variation in the significance of this symptom in the three age groups In our additional series of 47 cases 14 were severely prostrated and interestingly enough the only child in the group with an irreducible intussusception was not particularly prostrated

The appearance of prostration is fairly directly related to the duration of symptoms Of 79 cases of prostration in which data were adequate—

8 instances of prostration occurred in 44 patients (19%) who were ill less than 12 hours
13 in 35 patients (37%) in the 12 to 24 hour group
14 in 31 patients (45%) in the 24 36 hour group
10 in 13 patients (77%) in the 36-48 hour group
11 in 24 patients (46%) in the 48 72 hour group
11 in 20 patients (55%) in the 72 96 hour group
12 in 26 patients (46%) in the 96 hour and over group

As we shall see in the analysis of the relation of duration of symptoms to mortality there also is seen there a steady progress up to 96 hours after which there is a levelling off and a decline This is explained by the generally earlier application for treatment of the severe cases and the selective survival of the non strangulating cases

Dehydration

Dehydration was found to be marked enough to be noted in 51 out of 124 (41%) of cases in which there were adequate data prior to 1948 Of these 21 or 41% died There was no significant difference between the infants and the older children Of the 73 children who were not dehydrated 8/73 (11%) died Adequate data regarding dehydration were not given in 14 children who died It seems clear that had adequate data been available in this group the grave prognostic significance of dehydration would be even more strongly emphasized for as it is only eight patients died in whom the absence of dehydration was recorded on admission

Associated Diseases

It appears noteworthy that at the time of admission in 41/190 cases or 21% of the patients in whom there were adequate data there was found either otitis media or an upper respiratory infection or both on the admission physical examination. A number of authors have suggested that enlarged mesenteric nodes may be associated with upper respiratory infections and in their turn cause intussusception. Recently we have seen at another hospital an intussusception in a child with florid chicken pox.

Examination of the Abdomen

In a child with *the characteristic picture of* intussusception the abdomen early in the disease is flat or actually scaphoid. The intussusception occasionally forms a protuberance which is visible. Typically the abdomen is very soft and non tender although the child may wince when the intussusception is palpated and in such instances there may then be felt a little muscular resistance over the mass. *Palpation of the intussusception is the surest diagnostic* sign and one should expect to palpate the tumor almost invariably. Early in the progress of a characteristic intussusception the mass passes into the hepatic flexure behind the right costal margin and under the right lobe of the liver where it may be difficult or impossible to feel for some time. As time passes the disease picture is confused by the superimposition of the non specific signs of intestinal obstruction—distention and intestinal patterns which may obscure the mass. In a number of instances the mass was not definitely palpable until thrown into prominence by vigorous peristalsis during a cramp. An intussusception palpable before such peristalsis is felt to be much firmer at such a time. The mass is usually described as tubular, sausage shaped or cylindrical. The pull of the mesentery on the intussuscepted bowel between the layers of which it has been drawn constrains the tumor to arch in a curve.

Abdominal Resistance

Some 60% of the patients were said to show complete relaxation of the abdominal wall with no resistance or *spasm* anywhere. *Some resist*ance even though only over the mass was noted in 40%. Tenderness was noted in 41% of those with adequate data. In most of these the tenderness was noted directly over the mass. It will be seen that the figures are almost identical for the incidence of resistance and of tenderness. Presence or absence of distention was remarked upon in 186 cases. In 54/186 or 29%, a rather higher incidence than might be expected, distention was present. This is a reflection of course of the duration of the disease and of the appearance of signs of intestinal obstruction.

Mass

Data were adequate in 196 cases. In 167/196 *or 85% a mass could be felt either abdominally* or rectally. In most cases if a rectal mass was palpable an abdominal mass was felt as well but in ten of the cases in which a mass was felt it was felt only per rectum. In an occasional patient the abdominal mass was plainly visible. Thatcher reports a palpable mass in 85%, Cross in 85%, Thurston in 72% and Kahle in only 59%. A mass on palpation was found in 69% of Nordentoft's children under two years of age and in 73% of the older children. Snyder *et al* found a mass in only 69%.

Peristalsis

Mention of presence or absence of visible peristalsis was made in 135 cases. It was noted to be present in 24/135 cases or 18%.

Prolapse

In 7/199 or 3.5% of the cases the intussusception presented at the anus or beyond. It is customary to warn against mistaking a prolapsed intussusception for a mere rectal prolapse *in which latter* obviously the finger cannot be passed between the prolapsed bowel and the sheath of the intussusception, quite apart from the wide difference in the clinical picture in the two conditions. Other series report a substantially lower incidence of prolapse.

DURATION

The age of the pathologic process is an obvious determining factor in the production of necrosis of the bowel and other physiologic disturbances. It is of interest therefore that while in the last thirty years the promptness with which children with intussusception are brought to our hospital has indeed changed somewhat for the better our hospital mortality for the disease has first improved and then been eliminated without obvious reference to the modest decrease in the average duration of symptoms. A few cases of more than seven days duration are accepted as being typical chronic intussusceptions which might weight the results. In the period 1893 to 1909 patients averaged 56 hours from the onset of symptoms to beginning of definitive therapy and in the period 1910 to 1919 the time was 54 hours. In the next decade 1920–1929 there was substantial improvement to 45 hours. However the periods in 1930 to 1938 and 1940 to 1948 were still 28 hours and 38 hours. In the decade 1948–1958 the period from onset of symptoms to institution of treatment was 25 hours after we excluded from the computation three cases of chronic intussusception of 53, 22 and 21 days. Retained were two of 96 hours duration, one of 84 hours and three of 54, 52 and 50 hours (Fig. 6).

Duration of Symptoms at Various Periods and Mortality in Those Periods

Date	Onset to Treatment (Hours)	Mortality
1893-1909	56	75
1910-1919	54	71
1920-1929	4	41
1930-1938	28	29
1939-1948	38	9.4
1948-1958	25	0

Fig. 6. One Hundred and Ninety-nine Intussusceptions in the Johns Hopkins Hospital—1893 to 1958. There was a fairly steady decrease in the elapsed time from onset of symptoms to the institution of definitive treatments from 1893 (56 hours) to 1938 (28 hours) and a drop in mortality from 75% to 29%. Since then there has been little change in the duration of symptoms but a decrease in mortality from 29% to 0.

Figure 7 shows the relation of Mortality to the Duration of the Disease before the onset of definitive treatment. The current mortality is so low (in The Johns Hopkins series—no deaths 1946–1958) that it is only in the study of our earlier cases that this sort of information can be elicited. It is obvious that there is direct relation between the duration of disease before the onset of definitive treatment and mortality until one reaches the group with symptoms of 96 hours duration or longer. It is apparent that many of the children still alive with intussusception untreated for over four days must have had non-strangulating obstructions and that these carrying a better prognosis than the ordinary intussusceptions tended to decrease the mortality in this group. Only 4/52 children treated in 24 hours or less succumbed, a mortality (1893–1948) of seven per cent. In the 24 hour to 48 hour group 10/37 died or 27%. In the children in the 48 to 96 hour group 20/37 died, a mortality of 54%, but in children not definitely treated until 96 hours after the onset of symptoms only 7/23 died or 30%.

OCCURRENCE OF SPECIFIC LESIONS CAUSING INTUSSUSCEPTION

In our first 152 cases eight specific causative lesions were discovered. In five there was a polyp, in two there was a Meckel's diverticulum, in one an ectopic focus of pancreatic tissue. In the 47 intussusceptions since 1948 we have encountered one small enteric cyst at the ileo-cecal valve causing intussusception, three Meckel's diverticula and one unusually large discrete patch of ileal lymphoid tissue leading an intussusception. The total for the 199 cases is thus 13 such lesions, an incidence of 6 1/2%. It is significant that only three of these patients were less than one year old. Three were over a year old, one was two years old, one 2 1/2, one 3 1/2, one 4, two 6 and one was 11 years old. It is of course true that in the 75% of our recent cases in which the intussusception was reduced by barium enema alone we have had no opportunity to demonstrate the existence or absence of such mechanical lesions.

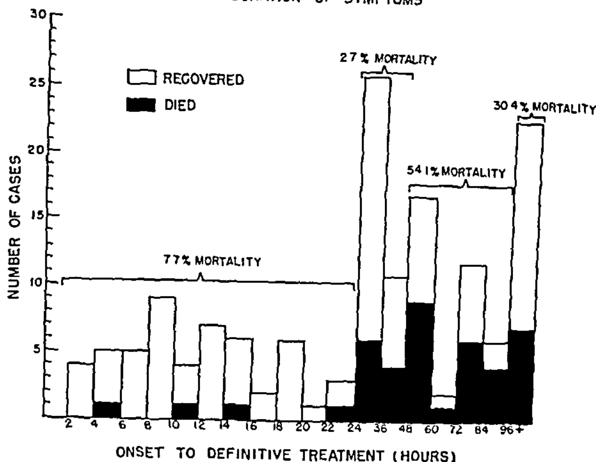


Fig 7 Intussusception—relation of mortality to duration of symptoms (1893-1948) *The deaths in the group of patients seen in the first 24 hours all occurred more than 35 years ago The mortality rises steeply in the succeeding hours* and drops suddenly after 96 hours This is due to the appearance at this point of cases of nonstrangulating *intussusception In the absence of any current mortality* it is only in the study of earlier cases that this sort of *information can be elicited (From Ravitch and McCune J Pediat 37 1950)*

nor have such lesions if they existed appeared to cause any difficulty

In two of the five children who had polyps the polyps were excised *In one the type of* operative procedure is not described and in one the involved segment was resected and that baby *died (of polyposis of the entire gastro intestinal tract)* and one died on the operating table before *operation could be performed The five patients in whom a Meckel's diverticulum* was found all survived after resection of the diverticulum or of the segment of the *bowel from* which the diverticulum arose A ten month old infant with a 50 hour old intussusception due to a nodule of ectopic pancreatic tissue had a bowel resection and died The enteric cyst was successfully resected with the cecum and terminal ileum *The large lymphoid focus was not* excised In general the specific lesions are rare and except in the desperately *ill should be excised if encountered at operation* In older children with intussusception or in any child with a recurrent intussusception the possibility of such a lesion must be considered

Lympho sarcoma is the occasional cause of a chronic type *of non strangulating intussusception* and the diagnosis may at times be ventured *in the presence* of a chronic intussus

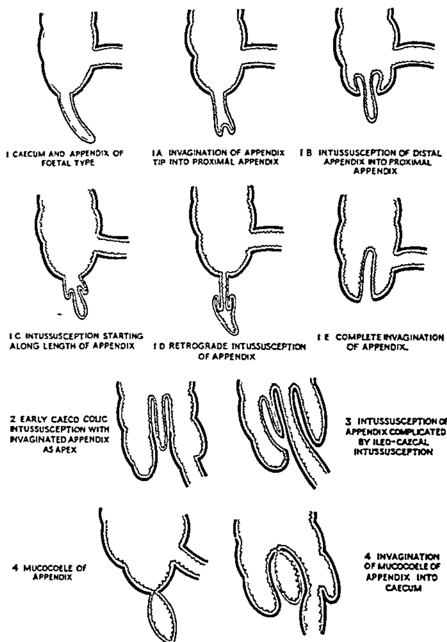


Fig 8 The Appendix in Intussusception

1 Intussusception of the appendix a The tip of the appendix forms the intussusception and is invaginated into the proximal appendix which forms the intussuscipiens The intussusception consists of only two layers—very rare b The invagination starts at the junction of the appendix and cecum The appendix forms the intussusception the cecum the intussuscipiens. This is the commonest type to which almost all appendicular intussusceptions belong c The invagination starts at some point along the length of the appendix—no recorded case d Retrograde intussusception—one recorded case e Complete invagination of appendix into cecum from progression of a b or c 2 Compound intussusception initiated by (1) a b or c The invaginated appendix leads the intussusception 3 Ileocecal intussusception complicated by appendicular intussusception but not led by it 4 The appendix without being turned inside out is invaginated into the cecum as in the so-called intussusception of a mucocele of the appendix 5 (Not shown) The appendix may be drawn into the general mass of any intussusception but provided the relationship of the appendix to the cecum is not altered (see frontispiece) this does not constitute an intussusception of the appendix 6 (Not shown) The stump of an amputated appendix may be the apex of an intussusception (From Forshall I Intussusception of the Vermiform Appendix *Brit J Surg* 1952)

ception which resides in the cecum At times the hypertrophied lymphoid patches in the terminal ileum which are thought to be responsible for many cases of intussusception assume such tumor like proportions as to invite resection Child and O Sullivan have reported such cases and we describe one above

The vermiform appendix may participate in or initiate an intussusception in one of a number of ways as Forshall has shown but ordinarily it is merely drawn into the space between intussusceptum and intussuscipiens and it is there compressed (Fig 8)

Cross and Ware in analyzing 610 cases of *intussusception* found a discernible mechanical factor in only 5 4% of the cases—twenty nine instances of Meckel s diverticulum four of intestinal polyps two of lymphoma of the bowel and one duplication of the terminal ileum There is no analysis as to the ages of the children involved

Thurston *et al* reporting 116 cases from the St Louis Children s Hospital found nine intussusceptions due to a Meckel s diverticulum and two more in which a Meckel s diverticulum was present but not involved in the intussusception In two cases there were adenomata of the ileum and in one a duplication cyst of the ileum

It will be noticed that we have made no mention of the various anatomical types of intussusceptions—ileo caeco-colic ileo ileo-colic ileo caecal etc We feel that no purpose is served by introducing these terms and that furthermore by fluoroscopy it is usually impossible to separate these and at operation frequently difficult Essentially it is important to know that 95% of all intussusceptions in infants and children begin at or near the ileo caecal valve and it is with these by and large that we are concerned Very few intussusceptions in children begin in the colon The symptoms in these are inclined to be less acute and on the other hand in the small number of intussusceptions which *begin far up in the* small bowel the symptoms are fulminating and the patients usually present as cases of intestinal obstruction of uncertain etiology rather than as cases of intussusception The reason for the occurrence of intussusception in the region of the ileo-cecal valve is disputed The disproportion between the sizes of the ileum and the cecum in infancy is greater than in later life and may perhaps more readily invite intussusception The frequent presence of large bodies of submucous lymphoid tissue in the terminal ileum may also explain the occurrence of some intussusceptions

No discussion of intussusception is complete without mention of the anatomical variant of the normal attachment of the cecum which goes by the name of cecum mobile While it is not *necessary to have a mobile cecum in order for* intussusception to occur it is obvious that the free progression of an intussusception around the colon and down into the rectum as frequently occurs would be impossible were the cecum to be *firmly fixed It is the relative mobility* of the cecum in many infants which permits the extensive progression of so many intussusceptions

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Chapter III

ERRORS IN THE DIAGNOSIS OF INTUSSUSCEPTION

In periodically reviewing our experience with intussusception we were struck some years ago by the fact that five deaths occurred in our experience between 1939 and 1946 all of these in patients treated primarily by operation What was most disconcerting was the discovery that in each of these five instances a serious delay had occurred in the initiation of definitive treatment In each instance the delay was caused by failure to diagnose the intussusception upon the patient's first visit to the hospital after the *onset of the condition In one child it is* true intussusception was only an incident in the course of an already established fatal disease but the other four children should not have died had *the* diagnosis been made promptly This experience led us to review the histories of the children in whom intussusception was improperly diagnosed at The Johns Hopkins Hospital in the period 1930 to 1951 in order to illuminate if possible the more common diagnostic pitfalls We now record a further review to 1958 and *combine the two groups*

By and large intussusception is a readily diagnosed disease with an easily recognized symptom pattern It is well to note that in many children the symptoms and signs of intussusception supervene during a mild illness such as an upper *respiratory infection or* a bout of non specific diarrhoea Those who feel that the presence of enlarged submucosal lymphoid masses predisposes to intussusception see a causal relationship here In any event, the possibility of intussusception may be thought of in a child who seems much sicker than his obvious upper respiratory infection or history of previous mild diarrhoea would suggest A few patients have strong and clear histories of previous similar attacks from which they *recovered spontaneously* Such a history should sharpen suspicion not allay it

Diarrhoea during the period of intussusception occurred in 15 or 7.5% of our entire series of 199 cases and 13 of these 15 patients were *under one year of age This is of extreme im*portance for there is an understandable tendency to assume that in the presence of intussusception there must be complete intestinal obstruction Of these 15 children the condition was actually mistakenly diagnosed in seven as dysentery and three of them subsequently died as the result of the delay In the period 1930 1958 121 children with intussusception were treated at The Johns Hopkins Hospital In 23 of these there was an *initial error in diagnosis* which affected the treatment and eight of these 19 children died all before 1946 With these brief facts and bearing in mind the pattern of history and physical examination in ordinary cases of intussusception as discussed *in detail* in Chapter II we may proceed to an analysis of the cases in which there was a diagnostic error with a significant ensuing delay A *study of this* kind obtains its chief value from an examina tion of the clinical characteristics *of the cases*

reviewed and does not lend itself to statistical tabulation so that it seems most profitable to discuss the cases in groups using the individual cases for illustration

Our errors in making the diagnosis have fallen into several categories One instance was that of a patient who showed all or most of the signs of an intussusception which was not recognized because of the ignorance of the examining physician In a second group the diagnosis was missed because of the rather long duration of the symptoms and the relative well being of the child There were five such cases in all of them the diagnosis was not entertained because the history went back for periods varying from a week to as much as 40 days during which the general condition of each child remained good Ultimately in each instance admission to the hospital was precipitated by the worsening condition of the child One must ever keep in mind the occasional occurrence of chronic non strangulating incompletely obstructing intussusception

One of the commonest errors was in making the diagnosis of dysentery based upon fever vomiting bloody stools and abdominal pain In this series there were seven patients in whom the erroneous diagnosis of dysentery was made When one considers how common dysentery is and how variable its manifestations it is small wonder this error was made One can only suggest that intussusception must be kept in mind

In two cases there was sufficient spasm rigidity and tenderness to simulate an acute abdominal condition requiring surgery In one a diagnosis of appendicitis seemed unequivocal with tenderness and spasm in the right lower quadrant no palpable mass and no bloody stool At operation the appendix was found to be normal and intussusception was found In the other case there was first tenderness in the right upper quadrant then considerable rigidity and consequently the possibility of appendicitis sickle cell crisis or other cause of abdominal pain and spasm was entertained Eventually after administration of secobarbital sodium a mass was felt and the diagnosis made by barium enema It is worth remembering therefore that abdominal spasm may be an important feature of these cases and may prevent early palpation of the mass

Palpation of the intussuscepted bowel should not be considered a sine qua non for the diagnosis In the group of 23 cases of delayed diagnosis 1930 1951 there were nine in which no mass was ever felt by abdominal palpation or by rectal palpation and ten cases in which there was a variable delay before palpation of a mass ultimately established the diagnosis In one case a palpable liver was repeatedly mentioned This may well have been the intussusception In two cases the mass was felt but thought to be a neoplasm or a cyst In some cases the mass was undoubtedly under the right costal margin and therefore not palpable In others it may have been obscured by distention and in still others by tenderness and spasm In 7 of the 23 cases the intussusception involved the ileum only In 4 of these no mass was ever felt

The age of the patient was misleading to the pediatrician in several instances Of the total group of 23 patients whose condition was initially misdiagnosed there were 8 patients over a year old including 7 over two years and there was one who was 2 weeks old Of the 199 cases analyzed almost 90% were under 2 years old and 57% were 4 11 months of age In this group of 23 children 7 or nearly a third were over 2 years old One tends to forget the possibility of intussusception in the older age groups as well as in newborn infants

Blood in the stools or currant jelly stools is another classic sign of intussusception That it may not appear in an appreciable number of cases is evident since it did not appear at all in 10 of our 19 undiagnosed cases Indeed in several cases the stools were normal or nearly so and in some others there were repeated watery stools In some cases there was occult blood in the stools and in others it was found only by rectal examination

In two cases and possibly a third the issue

was beclouded because the patients were already in the hospital with another disease. An additional case of this kind was seen recently in an infant admitted to another hospital with severe and flagrant varicella. It was thought by some observers that all of the symptoms could be explained by intestinal involvement in an enanthem and accurate diagnosis was delayed for several hours on that account.

Occasionally a blatantly typical case is misdiagnosed, as in the following instance.

P. G., a ten month old girl, was seen in the dispensary with a temperature of 101.8 and a history of fever, vomiting, and constipation for over 24 hours. An enema the night before had returned bright red blood. The abdomen was distended and there were no fecal masses, no tenderness, masses or spasms. Enema return in the dispensary was practically clear except that the water was tinged with light pink. Diagnosis were otitis media, chronic constipation, (?) intussusception. The child was sent home to return the next day. However the error was detected that night by the dispensary chief in a review of the day's histories and the baby was found and brought in 12 hours after the first dispensary visit. The child was now flaccid and almost completely unresponsive. A diagnostic barium enema filled the colon. Roentgenograms showed numerous loops and fluid levels and upon operation a short intussusception was found just above the ileocecal valve. It was not gangrenous but was irreducible. Resection and anastomosis were performed. The child's temperature rose to 40.4 C (104.8°F). She had convulsions for six hours and died. The specimen showed the intussusception to have been due to a nodule of aberrant pancreatic tissue.

This child had vomiting, constipation and blood in the bowel when first seen and consideration of intussusception should have been obligatory regardless of the absence of a mass which was all that was lacking. If the mere thought of intussusception is entertained a barium enema should be administered, and only if the small bowel fills readily and there are no fluid levels or distended loops may the possibility be dismissed. It is true that in this instance the intussusception was entirely in the small bowel, which makes for more difficult diagnosis and higher mortality. However films of the barium enema showed dilated loops and demonstrated the existence of a mechanical intestinal obstruction, a mandatory indication for operation in itself.

There was one other case of essentially inexcusable diagnostic inaccuracy which fortunately resulted in recovery. While everyone may at times fail to see the obvious, a high index of suspicion *in regard to intussusception* and a sense of urgency in the presence of the possibility of intussusception should reduce the number of diagnostic errors.

It is possible in some of the cases to see how the examiners were misled.

In six cases the duration of the illness was so long and the children in such good condition that the correct diagnosis was not entertained until late. These cases were of very different types.

The first case was that of a six year old child with a two year history of anemia, abdominal pain, anorexia and tarry stools with occasional vomiting. She had frequent attacks of abdominal pain when a mass was visible in the abdomen. Even though these attacks occurred during a hospital admission, intussusception seems not to have been considered. Laparotomy was finally undertaken and two separate intussusceptions were found, with polyps in each small bowel area.

This child had peculiar pigmentation (Hutchinson-Jeghers-McKusick spots) on the lips, the significance of which as indicating diffuse intestinal polyposis was not then realized. The chronicity of her complaint and the extensive blood loss due to the polyps had led to diagnosis of Meckel's diverticulum, ulcerative colitis, etc. In actuality repeated bouts of intussusception are a regular feature of the several syndromes associated with multiple small intestinal polyps.

Another patient celebrated in the annals of the Harriet Lane Home was an eight month old girl *whose initial dispensary visit was on the 11th day* of illness. This had begun with abdominal pain and a normal evacuation, followed after five hours by the passage of blood. She vomited every day, had fever every day and had one or two normal stools every day until the day of her first visit, when she had a bloody, watery stool. Examination showed

dehydration a palpable liver a fluid brown stool and blood in the rectum She was thought to have dysentery and was followed thereafter for 40 days during which she made 25 dispensary visits Some times she had diarrhoea sometimes not sometimes she vomited sometimes not sometimes she passed blood sometimes not She never failed to have a stool but often had bouts of pain The liver was usually palpable

She was finally admitted to the hospital where after three days a barium enema was given as part of the diagnostic study and was interpreted as normal The next day a mass was finally felt Barium enema reduced a typical intussusception from the transverse colon to the ileocecal valve and reduction was completed at operation The child had no trouble thereafter Review of the first roentgenograms which had been read as normal actually showed a typical chronic intussusception (Fig 9)

In this instance despite innumerable bloody stools bouts of pain and vomiting the possibility of intussusception was ignored because of the long history and the absence of obstruction in an eight month old infant who was obviously not desperately ill

The next child in the group with chronic intussusception was a one year old girl with vomiting and constipation of one week s duration and with a history of flecks of blood in an enema and repeated bouts of periodic abdominal cramps The abdomen was distended a roentgenogram showed dilated loops and intestinal obstruction was suspected but because her condition seemed exceptionally good she was sent home to return the next day! She was then distended there was tenderness and spasm in the right lower quadrant and the suggestion of a mass She was thought to have a low intestinal obstruction Barium enema showed an intussusception in the right lower quadrant for which operation was undertaken The intussusception was reduced

In this instance the picture was largely that of intestinal obstruction for which admission and operation should have been advised in any case

The fourth case of delayed diagnosis in a child with a long history was that of a 2¼ year old girl who had a ten day history of illness This had begun with sudden severe cramps which persisted at frequent intervals She vomited after almost every meal but she had normal stools without any blood for the two days preceding admission She was thin dehydrated and crying with frequent spasms of abdominal pain There was much audible peristalsis Hard dry feces lay in the rectum There was tenderness and muscle spasm in the right upper quadrant and a poorly defined tender mass She was observed for 12 hours for ( ) lead poisoning (r) appendiceal abscess until a diagnostic barium enema showed an intussusception at the hepatic flexure Operative reduction was successful

There seems little justification for the delay in operation although the absence of bleeding and distention are extenuating factors and although the mass must have been partly concealed by the liver and the right costal margin

The fifth child in this group was a six month old boy with a three month history of cramps and vomiting occurring in episodes He had daily stools and never passed blood Three days before admission a tubular non tender mass in the left upper quadrant was felt and taken to be an enteric cyst Upon operation this mass proved to be an intussusception at the splenic flexure When it was reduced a mass at the ileocecal junction was discovered and resected and turned out to be a small enteric cyst which had led the intussusception

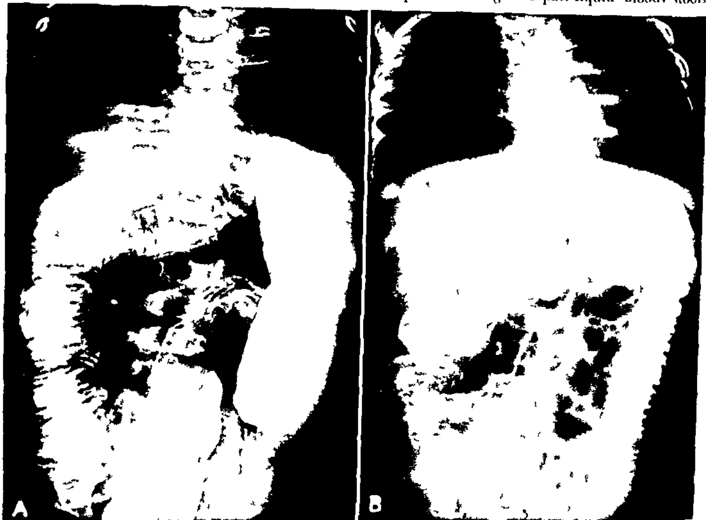
The sixth case in this group is similar to the fifth A five month old boy was seen by his physician 24 hours after onset of vomiting and constipation and having failed to respond to a change in formula was seen at the hospital after another 18 hours He did not appear ill was only slightly dehydrated afebrile A firm round movable mass was felt in the right mid abdomen He was considered for six hours to have an abdominal neoplasm before a barium enema was finally administered and the intussusception in the mid transverse colon encountered and reduced

The most interesting feature common to all these children is that despite the fact that they had long standing intussusceptions from one or two days to others varying in duration from ten days to a month or more all survived and none had gangrenous bowel This is inherent in the nature of chronic intussusception A moment s reflection will show that precisely those children will have chronic intussusception of long standing whose intussusceptions do not become

gangrenous and in whom neither the intestinal canal nor its vascular supply becomes completely obstructed One should not insist upon feeling a mass before resorting to barium enema The mere fact of a long history in a child who is still in tolerably good general condition does not exclude intussusception and the child may continue to pass stools daily By the same token in these cases bleeding into the bowel may be inconspicuous or absent

A very small group is represented by two children who were already in the hospital and seriously ill when intussusception supervened

An 18 month old boy was in the hospital dying of malnutrition as a result of diffuse polyposis of the entire intestinal tract This had resulted in almost constant diarrhoea In the ward a long time after admission he spent a bad night with abdominal pain and began to pass liquid bloody stools



Chronic Intussusception

Fig 9 C B Female 8 months old This child was first brought to the hospital 14 days after a bout of abdominal pain followed by passage of bright red blood She had vomited daily had fever lost appetite but had continued to have one to two bowel movements a day some watery and with blood She had lost 3 pounds. She was seen on 25 separate visits to the hospital On the first visit it was noticed that she had what was thought to be a palpable liver and upper abdominal fullness. Her visits were usually occasioned by fever vomiting diarrhoea and bloody flecks in the stools. She was finally admitted to the hospital 3 days after the first visit for this complaint On only one or two occasions in her dispensary visits had no mass been felt She had appeared a puny child and had generally been thought to have hepatomegaly Her admission diagnosis was dysentery She had lost weight and had never stopped vomiting On admission she was described as having a soft liver with rounded edge two or three fingers breadth below the costal margin Three days after admission the mass was identified as being sausage shaped and conceivably an intussusception and a diagnostic barium enema was requested of the Radiology Department No surgical consultation was requested The

(Continued on next page)



Fig 9 (Cont)

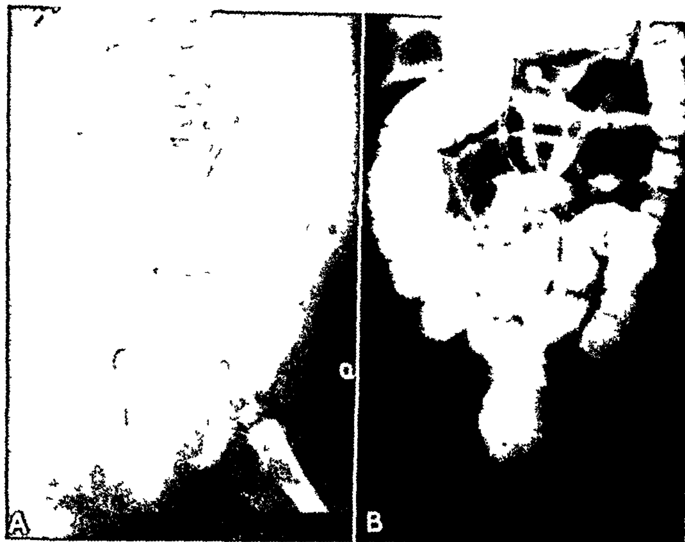
mass apparently disappeared just before the roentgenogram was taken and the characteristic findings seen in this film were not appreciated The following day the mass was palpated once more and the diagnosis confirmed on surgical consultation Barium enema reduction demonstrated a typical intussusception at the splenic flexure which was readily reduced to the cecum beyond which it could not be moved Through a small McBurney incision the cecum was delivered and less than a centimeter of bowel appeared to be still intussuscepted This was readily reduced There remained so much edema at this point that the bowel was opened found to be normal but for the edema and closed The appendix was removed the child left the hospital well eight days later The coiled spring appearance is typical of a chronic intussusception The edema of the non strangulated bowel produces the large ring like filling defects in the barium which enters between the intussusceptum and the intussuscipiens The absence of complete intestinal obstruction does not rule out the possibility of intussusception The commonest erroneous diagnosis leading to delay in the treatment of intussusception is dysentery

A This was a diagnostic study undertaken when the diagnosis of intussusception was not very seriously entertained Although barium reaches the right lower quadrant the characteristic coiled spring appearance is seen from the splenic flexure around to the right lower quadrant

B With expulsion of some of the barium what is presumably cecum seems empty and the coiled spring chronic non strangulating non-obstructive intussusception is seen in the transverse colon and hepatic flexure

C Enlargement of B to show the coiled spring more clearly

It is probable that the intussusception moved back and forth for a month or more almost reducing entirely at times passing far around the colon at others (From Ravitch *Am J Dis Child 84* 1952)



Intussusception Superimposed on Other Disease

Fig. 10. C. B. Male, fifteen months old (B. C. H.). This child had been ill at home for a week with an upper respiratory infection and the obvious manifestations of chicken pox. During this period he had vomited several times. The day before admission he began once more to vomit and became distended. He had had abdominal pain from time to time during this entire week. At the time of admission he had the flagrant rash of chicken pox. In spite of the history of abdominal pain and vomiting it was assumed that the distention was due to involvement of the bowel with the exanthem of varicella and it was 24 hours before a barium enema was undertaken.

A. The plain film shows numerous dilated loops of small bowel and no loop identifiable as colon.

B. The colon filled readily without demonstrating an intussusception but a peculiar shadow was seen in the small bowel (just opposite the bend in the gastric tube in the film) when the rectal catheter was withdrawn and the patient allowed to evacuate the excess barium.

(Continued on next page)

After 21 hours a mass was felt in the right upper quadrant. The mass developed rapidly. It was explored and found to be an ileoileal intussusception. The child died 21 hours after operation. At autopsy the entire bowel, from cardia to anus, was found to be studded with these polyps.

A nine month old girl was admitted with a two week history of green diarrheal stools, blood in the stools, fever, cough and persistent vomiting. There was right upper lobe pneumonia. The child was very dehydrated, the eyes and the fontanelles were sunken. The abdomen was scaphoid. The temperature was 40.8 C. (105.4 F.). The abdomen became tympanitic and distended almost at once and she began to pass gross blood in the stools with much mucus. After 72 hours she was markedly distended and sicker, despite clearing of the pneumonia. Barium enema was normal but she was having repeated currant jelly stools. Upon operation a necrotic ileoileal intussusception was found and resected, death eventuating.

In both these instances, intussusception devel



Fig 10 (Cont)

C The colon was seen to be filled completely as well as a few inches of terminal ileum Proximal to this was the sausage shaped double shadow of an unreduced intussusception Operation was immediately undertaken An irreducible ileo ileal intussusception was resected and primary anastomosis performed

The child recovered without incident Such radiologic demonstration of an intussusception in the ileum is rare The plain films showing dilated small bowel loops and no gas in the colon should have led to operation for intestinal obstruction

oped in a child already seriously ill and in the hospital and the diagnosis was delayed because the child was already in the hospital on another account Members of the staff were slow to appreciate the significance of the change in symptomatology It is possible of course that the second case was one of intussusception from the first although there appears to have been a sharp and sudden change in the clinical picture

A recent case involves another instance of preexistent and coinciding disease seen in another hospital

A 14 month old boy was admitted to the hospital with obvious chicken pox and abdominal distention Seven days before he awakened from a nap like a wet dish rag and vomited He had a normal stool that night but slept poorly For the next three days he ate poorly vomited often and slept a good deal and after three days without a stool passed a reddish watery movement He began to improve eating better vomiting less when he developed a rash and abdominal distention The rash was characteristic of chicken pox there was a soft distention of the abdomen and a watery mahogany colored stool

Intussusception was at once thought of but the obvious varicella and the prolonged history in a child still in relatively good condition led to the suggestion that the problem was one of paralytic ileus due to the presence of intestinal enanthems It was 24 hours before a barium enema revealed not only the distended loops of bowel which had been attributed to paralytic ileus but a characteristic filling defect in the terminal ileum (Fig 10)

At operation a gangrenous intussusception of the terminal ileum was resected The specimen does not show any unusual features The child made a rapid recovery

In this instance the existence of florid chicken pox led to the dismissal of a fairly characteristic history of intussusception and the erection of a labored clinical structure attributing the distension to paralytic ileus and visceral chicken pox and the bloody stools to ulcerated enanthems Barium enema fortunately outlined an intussusception in the ileum—a rare event

The largest group and the most deceptive consists of the babies who were first thought to have dysentery and finally were found to have intussusception There were eight of these children When the variable character of early dysentery in infants and children is remembered this error does not seem so remarkable *although again it is preferable to conduct barium enema studies on the mere suspicion of the possibility of an intussusception*

A ten month old baby was admitted to the dispensary with a temperature of 103 1 F after 24 hours of vomiting while the stools were normal the throat was red the eyes sunken and the child was restless She was treated for dysentery in the pre-diarrhoeal

stage The next day with a temperature of 106 6°F she was admitted to the hospital She was very well nourished to the point of obesity and seemed fairly well There was tenderness and resistance in the right upper quadrant She was thought to have a paralytic ileus of unknown origin Roentgenograms showed dilated loops Two days after admission laparotomy showed a gangrenous intussusception which was resected The child died soon after

In this instance obesity of the child interfered with abdominal palpation and with accurate assessment of the condition There appeared from the record to be a constant search for real abdominal rigidity in a ten month old infant It is well known that in young infants there may be little or no abdominal resistance in acute abdominal lesions The presence of constipation distention and vomiting were not properly evaluated

The next child also died He was a six month old infant with a 18 hour history of bloody stools vomiting and crampy abdominal pain He was in shock bleeding from the rectum and severely dehydrated Rectal examination showed bloody mucus It was discovered that the child had been offered egg for the first time on the day of onset and therefore time was taken to test his allergy to egg albumin which proved minimal Roentgenograms showed dilated loops and after several hours operation was undertaken At operation an ileoileal intussusception was discovered and reduced His temperature rose to 41 6 C (106 8 F) and he died perhaps as a result of scanty supportive treatment having received only a little dextrose before the operation and only 100 cc of blood after the operation

In this instance a delay of a few hours was occasioned by neglect of the obvious indications of intussusception with a clear clinical picture except absence of a mass The intussusception was ileoileal The time which was wasted could have been employed in vigorous transfusion therapy

The third child mistakenly thought to have dysentery was eight months old He came to the hospital shortly after having passed four watery yellow stools and having vomited several times He was obviously acutely ill and was sent home as having dysentery Next day he appeared to be having cramps and had a bloody mucous stool There was now a mass in the right upper quadrant Barium enema reduced a typical intussusception to the right colon whence reduction was completed at operation

The fourth infant in the dysentery group came to the dispensary after 18 hours of vomiting and no stool He was thought to have an acute nutritional disturbance he was given fluids intravenously and feedings were ordered withheld Several hours later he was brought back to the hospital with colicky pain and a right upper quadrant mass there was blood on the finger after rectal examination Barium enema reduced the intussusception to the cecum and operation completed the reduction

In this case vomiting and the fact that the child had been one day without a stool were all there was to arouse suspicion but a barium enema might have been advised because of the question of intestinal obstruction

The fifth child in this group an eight year old boy had a ten hour history of severe cramps with vomiting and several watery stools with mucus and blood The abdomen was rounded and slightly distended Rectal examination yielded a liquid stool with blood mucus and white blood cells The diagnosis upon admission was dysentery but after several hours a barium enema was done which showed an intussusception in the descending colon which was readily reduced by hydrostatic pressure

The sixth child in this group was a seven month old girl with a two week history of vomiting having ten to twelve diarrhoeal stools a day fever and anorexia Blood appeared in the stools the day before her first visit and on that day she had only three to four stools The temperature was 101 1 F She was irritable toxic and slightly dehydrated and the ear drums were red and bulging The liver was felt two centimeters below the costal margin A myringotomy was done and she was sent home The next day she was vomiting and had a loose purulent stool a tender abdomen and a rectal prolapse She was admitted and the following day a barium enema showed a normal colon but distention increased and stools ceased altogether At operation an ileoileal intussusception was reduced The child seemed to be recovering when colon bacillus meningitis developed and she died

Her cramps vomiting and tenderness had been ignored and it is possible that the liver was the intussusception Intussusceptions which do not enter the colon are radiologically and

clinically difficult to diagnose Cramp like pain vomiting and distention should have suggested mechanical intestinal obstruction It is infinitely more costly to delay operation for mechanical intestinal obstruction until diagnosis is absolutely certain than to operate occasionally for what proves not to have been an obstruction

The seventh child mistakenly thought to have dysentery was a five month old girl first seen at the hospital a few hours after the sudden onset of vomiting and diarrhoea Blood appeared in the stool after her first hospital visit Finally admitted 48 hours later she was prostrated weak lethargic dehydrated A mass was felt in the left lower quadrant and reduced by barium enema and she recovered Her case is described in detail in Chapter V under Complications of Barium Enema Treatment

The eighth child in this group was an eight month old boy whose illness began with a sudden bloody diarrhoea Seen soon after he was passing bloody watery yellow stools and although exhibiting periodic cramps and vomiting repeatedly was sent home on sugar water On his return the next day he was profoundly prostrated severely dehydrated and acidotic A mass was easily palpable in the left lower quadrant The intussusception was reduced by barium enema from the sigmoid to the ascending colon and further reduction completed at operation

A ninth child with diarrhoea six weeks of age had been followed at the Harriet Lane Home and Dispensary for most of its brief life with constant diarrhoea and occasional bleeding

The child was admitted to the Baltimore City Hospital moribund and with a profound marasmus Despite the continuing diarrhoea because there was now blood in the stools a barium enema was advised The plain film showed numerous distended loops of what appeared to be small bowel with no recognizable loops of colon A barium enema was undertaken and no intussusception was recognized A subsequent review of the films (Fig 11) showed an obvious meniscus in the ascending colon with the suggestion of a compound intussusception The final films showed incomplete filling of the colon although there was a little dribble of barium into the ileum For this reason operation was insisted upon The intussusception was found to have been completely reduced by the barium enema only a cyanotic annualar ring in the ileum some inches proximal to the ileo cecal valve indicating the previous presence of the intussusception

The child marantic and moribund on admission from its long diarrhoea continued in its previous state for two days and died Autopsy showed an extensive and profuse enteritis

In one child a girl of 29 months an attempt was made to establish the diagnosis of meningitis She was admitted to the hospital 18 hours after the onset of vomiting and cramps She was markedly distended and intestinal pattern and peristalsis were conspicuous nevertheless in the absence of a mass or of blood in the rectum her extreme listlessness and drowsiness suggested a central nervous system disorder such as encephalitis or meningitis Lumbar puncture was negative After five hours a barium enema was performed and showed multiple fluid levels a stepladder pattern and a typical intussusceptum at mid transverse colon reduced to the ileum At operation the ileoileal component was reduced manually The child remained stuporous for days before recovering and it is not impossible that we were dealing with intussusception supervening in a child with encephalitis

At least three children suffered a delay in diagnosis because of a compound error it was or should have been evident that some other form of mechanical intestinal obstruction might be present or some other acute abdominal process yet the child was not admitted to the hospital for immediate operative treatment

One child of six years was seen after 18 hours of periumbilical pain and vomiting with no stool in the second 24 hours The liver was thought to be palpable An enema was ineffectual but the child was sent home He was brought back the next day markedly ill dehydrated and distended with numerous dilated intestinal loops It was thought that he might have peritonitis and ileus but operation showed a large ileocecal intussusception which was resected Death followed soon after operation

A four year old boy with a similar history was more fortunate He had a two day history of abdominal cramps was sent home and returned in 24 hours having vomited several times There was a little spasm in the right upper quadrant and active peristalsis He was sent home again and returned the next day with cramps distention and right upper quadrant tenderness and spasm With the child under sedation with secobarbital sodium a typical intussusception was felt Barium enema reduced it



Intussusception Misdiagnosed Dysentery

Fig 11 D L. Female six weeks (*B C H*) This baby was admitted to the hospital moribund with a history of diarrhoea for most of its brief life and occasional bleeding Despite the continuing diarrhoea because there was blood in the stools a barium enema was advised

A The plain film shows numerous distended loops The colon is not recognizable

B The observers did not note any intussusception under the fluoroscope but this film shows an obvious meniscus in the ascending colon and suggests also that there may have been a compound intussusception with the colocolic portion in the transverse colon in process of being reduced at this point

(Continued on next page)

to the cecum and operation completed the reduction

In this instance the boy was twice sent home despite rightsided abdominal tenderness and a history of cramps for which admission and operation should have been advised from the first

By contrast with these cases there is the following case history —

A 3½ year old white boy had a twelve hour history of generalized abdominal pain nausea and vomiting with no stool in that time There were tenderness and rigidity in the right lower quadrant Operation for appendicitis was promptly undertaken An intussusception was found to have passed into the ascending colon and reduction and cure were readily accomplished

Intussusception had not been suspected and no barium enema was performed but operation was undertaken without delay and the result was good

There was one fatal case in which we see no opportunity for the diagnosis to have been made —

A two week old infant with diarrhoea had been having up to seven or eight stools a day since the second or third day of life There had been no vomiting and no blood in the stool He had taken

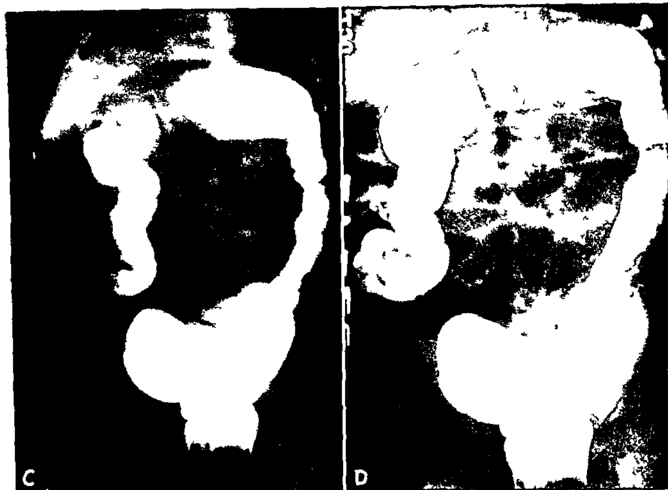


Fig 11 (Cont)

C & D The colon appeared to fill incompletely and although a little barium passed into the ileum there was a failure of the ileum to fill freely On this account after a review of the films several hours later operation was insisted upon The intussusception was found to have been completely reduced and only a cyanotic annular ring in the ileum some inches proximal to the ileo cecal valve indicated that intussusception had been present

The child marantic and moribund on admission from its long diarrhoea continued in its previous state for two days and died Autopsy showed an extensive and diffuse enteritis

feedings until four days preceding admission The abdomen was soft There was no vomiting and no distention At autopsy a gangrenous intussusception in the midileum was found

It is worthy of note that in 7 of the 23 cases of mis-diagnosed intussusception the intussusceptions were definitely ileoileal and had not yet involved the colon This being a disproportionately high figure in view of the low incidence of such intussusceptions in the entire series it must be assumed that there is a direct connection between the occurrence of ileoileal intussusception the difficulty in diagnosis and the high mortality There have been 16 deaths in the 121 cases of intussusception since 1930 and in 8 of these the intussusceptions were ileoileal The incidence of intussusceptions beginning high in the small bowel was 10% or less in the entire series further emphasizing the special character of such intussusceptions

Errors in diagnosis of intussusception occurred in at least 23 cases in our hospital since 1930 these errors were associated in 22 cases with significant delay in treatment In the 23rd case appendicitis was thought to be present and upon operation the intussusception was found and re

lieved Errors in diagnosis were based on a number of misconceptions In some cases a history of days or weeks of pain vomiting constipation etc with relative well being was not recognized as characteristic of chronic non strangulating intussusception In 8 cases the passage of feces even to the point of diarrhoeal stools was enough to lead the examiners astray *with the suspicion of dysentery* In several cases intestinal obstruction of uncertain type was thought to exist but operation was inexplicably not immediately undertaken On the one hand, in many of the cases too much stress was laid on failure to feel a mass while on the other hand an enlarged liver was palpated in several cases and insufficient weight was attached to a finding of slight abdominal tenderness or resistance In some cases the absence of currant jelly stools apparently encouraged delay but in others pink enema returns or a history of blood in the stools failed to alarm the observers

In three cases the children had established diagnoses of other disease pneumonia diffuse intestinal polyposis varicella and this delayed the recognition of a supervening intussusception

If we are to lose no children from intussusception early accurate diagnosis is required This calls for a high measure of suspicion and a ready resort to barium enema and plain roentgenograms of the abdomen in doubtful cases A barium enema which runs into the distal ileum rules out the ordinary type of intussusception at the ileocecal valve but does not rule out one higher in the ileum The latter will usually show distended gas filled loops in the roentgenogram Mechanical intestinal obstruction from any cause requires early relief by operation Alertness to advise early operation for *suspected intestinal obstruction will benefit the* patients with obstruction far more than it will harm the occasional patients who will prove to have been unobstructed Had this practice been followed in the cases reported above it might have saved a number of children in whom intussusception produced a picture of intestinal obstruction the importance of which was minimized

The last death in this group occurred more than 12 years ago evidence of a trend towards more accurate diagnosis and more vigorous early treatment

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Chapter IV

PATHOLOGICAL AND EXPERIMENTAL STUDIES IN INTUSSUSCEPTION

Despite widespread interest in the clinical aspects of intussusception there have been few experimental studies of the problem In 1893 Nicholas Senn found that manually produced intussusceptions in cats would reduce spontaneously if not fixed by sutures He reduced experimental intussusception by insufflation of hydrogen gas and considered this the preferred method of therapy in patients Senn s studies are perhaps the only ones before our own dealing specifically with the mechanism of reduction of intussusception by gas or fluid pressure and aimed at establishing the utility and safety of this method of therapy He was inclined to think that gas was a good deal safer than fluid but this may have been due to a certain prejudice held by him in favor of the use of hydrogen gas in surgery He had recently demonstrated experimentally in dogs wounded by pistol shot through the abdominal wall that if hydrogen gas were insufflated into the intestine it would escape from the intestine and out the abdominal wound where its presence could be demonstrated by lighting it with a match This test Senn recommended for use in clinical instances of penetrating wounds of the abdomen in order to permit early diagnosis of perforation of the intestine so as to justify operative intervention

D Arcy Power in a magnificently comprehensive Hunterian lecture in 1897 described his own experimental work with guinea pigs cats and rabbits He found difficulty in producing intussusception by means of cathartics and other pharmaceuticals Intussusceptions which he produced manually were usually not dramatic in their results for his animals tolerated such intussusceptions fairly well Nothnagel in 1904 found in cats and rabbits that steadily maintained faradic stimulation produced a tetanic contraction of bowel which occasionally caused the bowel to telescope into the segment distal to it He was chiefly interested as was Senn in the mechanism of producing intussusception Both of them noted that the intussusception developed at the expense of the sheath the leading point not altering D Arcy Power s interests were more far reaching and his observations more detailed than those of Nothnagel or Senn

Watts and Fulton in 1934 reported the production of intussusception in monkeys by faradic stimulation of the pre motor area of the cerebral cortex

There are a number of observations from the experimental laboratory reporting that dogs with one or another type of chronic experimental renal preparation are prone to the development of intussusception Houck and his associates found that 11 out of 36 dogs maintained from 6 to 111 days on a low salt diet and peritoneal dialysis after a bilateral nephrectomy devel

oped intussusception Selye mentions intussusceptions as frequent complications in very young dogs following a constricting ligature on one renal artery

Grollman and his colleagues found intussusceptions in 11% of 71 bilaterally nephrectomized dogs whether untreated or subjected to the artificial kidney In Houck s studies nine of the intussusceptions were single two were dual ten were forward and one was retrograde The intussusceptions occurred from the 2nd to the 5th day after nephrectomy some progressed to gangrene and some protruded through the anus In many of the dogs hyperemia congestion epithelial hemorrhages and edema in the mucosa of the intestine appeared and were interpreted as the possible causes of intussusception together with visceral peritoneal irritation from the dialysis fluid This could not be the explanation in Selye s and Grollman s animals

Furthermore some years ago in performing bilateral cutaneous ureterostomies in young puppies by bilateral extra peritoneal operations we found fatal intussusception a common complication of our studies It seems probable that renal lesions of the kind under discussion are associated with intestinal hyperperistalsis which leads with some frequency to the development of intussusception

A great mass of clinical experience has been acquired over the past 85 years in the treatment of intussusception both by operation and by reduction with hydrostatic pressure The bulk of this material demonstrates adequately to us by pragmatic test the safety and superiority of primary reduction by hydrostatic pressure Two of the gravest objections raised to the method are that gangrenous bowel may be reduced and that bowel may perforate under pressure during reduction Some years ago in association with

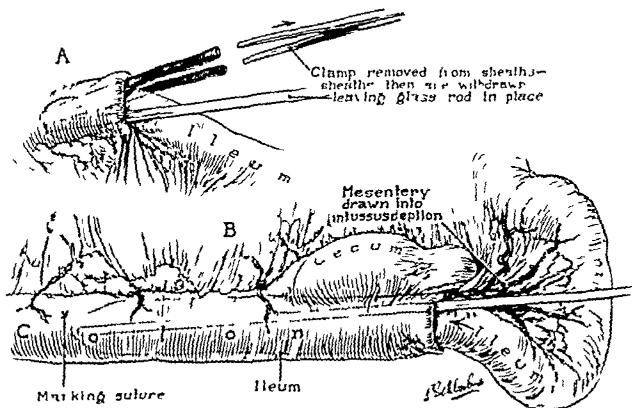


Fig 1. Experimental Intussusception in Dogs The ileum has been stimulated by a current from an induction coil applied some 14 centimeters from the junction with the colon The spastic segment has been grasped with rubber shod forceps and invaginated into the distal bowel A smooth glass rod is placed alongside the forceps the forceps are slipped out of their sheaths and the sheaths then removed With the glass rod the intussusception is advanced 15 centimeters at the expense of the recipient loop—the intussuscipiens A silk suture in the colon marks the level of the intussusceptum (From Ravitch and McCune *Bull Johns Hopkins Hosp* 8? 1948)

Dr Robert M McCune Jr studies were undertaken to determine experimentally the likelihood of such mishaps and to observe the pathological changes in the clinical course of intussusception in animals

Attempts to produce intussusception were made by painting the ileum with barium chloride and then invaginating the contracted bowel with rubber shod clamps In some animals prostigmine was then injected into the corresponding mesenteric artery The prostigmine produced no obvious effect upon the intussusception Intussusceptions produced in this manner were irreducible by enemas as soon as 7 or 8 hours later This we attributed to the instrumental trauma to the bowel with resultant adherence of the adjacent coats

The final procedure was as follows employing adult dogs under general anesthesia and operating with sterile technique The ileum 14 centimeters above the junction with the colon was stimulated by a faradic current from an induction coil While the bowel was still contracted strongly it was seized by rubber shod forceps and inverted into the distal segment If the entire intussusception was produced in this manner the serosal surfaces were sufficiently traumatized so that firm adhesions developed within 12 hours making the reduction impossible by hydrostatic pressure and difficult by di



Fig 13 Experimental Intussusception in Dogs Cross specimen of RM 9 dying of irreducible intussusception The intussuscipiens and intussusceptum have both been opened Note the dilatation of the iluem proximal to the intussusception and the narrow constriction at the proximal end of the intussusception The mucosa of the inner most layer of the intussusceptum is well preserved and undiscolored The outer layer of the intussusceptum is swollen discolored and the changes are more marked at the tip of the intussusception The outermost layer the intussuscipiens is grossly normal



Fig. 14 Experimental Intussusception in Dogs Cross specimen of RM 52 Irreducible intussusception at 18 hours The outer layer of the intussusceptum is plainly gangrenous and the changes conspicuously more advanced at the tip than proximally (From Ravitch and McCune *Bull Johns Hopkins Hosp* 82 1948)

Fig. 15 Experimental Intussusception in Dogs. The intussusception has prolapsed through the anus (A) and is gangrenous while within the abdomen (B) there is seen a spontaneously produced colo-colic intussusception in the same animal The experimental intussusceptions produced presented at least as severe a condition as that seen clinically and provided a suitable test of the possible hazards of hydrostatic reduction (From Ravitch and McCune *Bull Johns Hopkins Hosp* 82 1948)


A


B

rect manipulation The intussusception therefore was only initiated with the forceps (Fig 12A) the forceps then being replaced by a smooth glass rod and the intussusception completed with this instrument (Fig 12B) which was readily withdrawn without damage to the opposed serosal surfaces Intussusceptions of some 15 centimeters in length were regularly produced The level of the distal end of the intussusception was always marked by a silk suture in the serosa of the intussuscipiens The neck of the intussusception was usually at the ileo colic junction or just proximal to it

Because the cecum of the dog is firmly fixed to the posterior parietes there was usually not much progression of the intussusception In two instances the intussusception became compound developing a colocolic component which by shortening the colon permitted the intussusception of the ileum to prolapse through the anus In two instances the intussusception was reduced spontaneously In two others the intussusceptions did not become gangrenous and the animals suffered only from partial intestinal obstruction All the other animals gave clinical evidence of intussusception—anorexia vomiting passage of bloody mucus per rectum and finally death unless the intussusception was reduced In animals coming to operation the gross pathological picture was much like that in the human In a number of dogs 6 to 8 hours after production of the intussusception 30 cubic centimeters of castor oil was given by stomach tube in the hope of aggravating the intussusception Untreated animals usually survived over 18 hours A total of 14 dogs succumbed to unreduced intussusceptions Six of these intussusceptions were produced by the earlier and more traumatic method with an average survival of 71 hours Eight others had intussusception produced by the gentler method with the glass rod and survived an average of 88 hours

After intervals of 18 28 38 and 48 hours the dogs were anesthetized with ether and the abdomen reopened The serosal surface of the neck of the intussusception was cultured A balloon catheter was placed in the rectum the balloon distended and saline solution permitted to enter the rectum from a height of 3 feet The pressure was maintained for 5 minutes If reduction was not achieved the colon was allowed to evacuate and after 5 minutes the process was repeated If reduction was still not achieved a third attempt was made This technique followed the clinical technique of hydrostatic pressure reduction which we employed at that time It later became apparent that it was simpler and more effective to maintain hydrostatic pressure without remission rather than emptying the bowel repeatedly

If the intussusception was reduced the serosal surface of the bowel was cultured again this time at the level of the original apex of the intussusception In any case the abdomen was closed and the dog permitted to recover from the anesthesia The majority of the dogs whose intussusceptions were completely reduced by hydrostatic pressure had uneventful recoveries the dogs in the 38 hour group experiencing the greatest difficulty When the clinical signs of intussusception were present before reduction—anorexia vomiting listlessness passage of blood per rectum they disappeared within 24 hours after reduction Some dogs passed soft unformed stools for a few days afterward Otherwise the dogs remained entirely normal to gross observation Six of the 10 dogs with irreducible intussusception of 48 hours showed a progression of their preoperative signs—vomiting listlessness tachycardia passage of blood per rectum and soon became unresponsive and moribund and died 3 or 4 days after production of the intussusception Two of the 10 dogs with irreducible intussusceptions at 48 hours had chronic intussusceptions and showed little more than occasional vomiting and constipation though one did show great weight loss by the end of two weeks Two dogs of the 48 hour group died under anesthesia Two dogs showing spontaneous reductions at 48 hours and the dogs successfully reduced at 48 hours recovered uneventfully Two dogs dying in less than 18 hours before reduction could be attempted

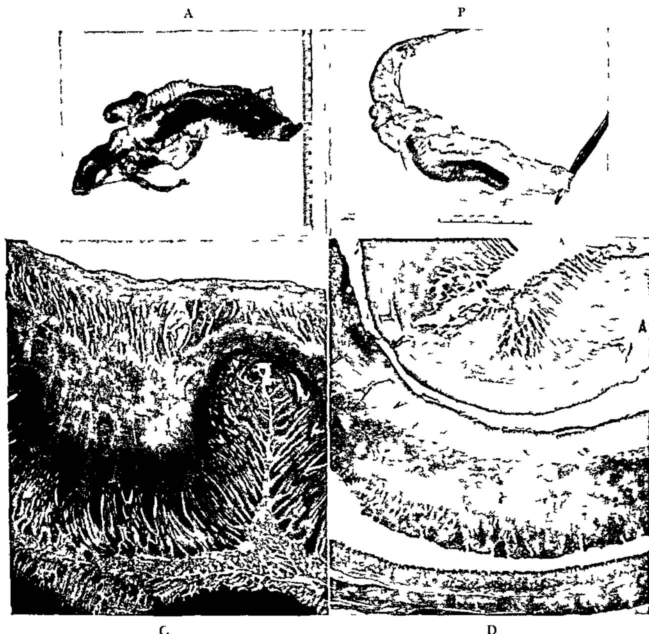


Plate I A RM 28 Experimental Intussusception in Dogs Intussusception irreducible at 48 hours Dog survived Specimen removed at 14 days The lumen through the intussusceptum was narrow but patent There was no gangrene at this time but the mucosa of the intussusceptum had sloughed from the returning coat particularly near the apex

Plate I B RM 34 Experimental Intussusception in Dogs Dog died at 43 hours The apex of the intussusceptum is gangrenous the remainder hemorrhagic and swollen The ensheathing intussuscipiens is essentially normal

Plate I C RM 22 (X30) Experimental Intussusception in Dogs Intussusception of 28 hours duration Reduced by enema Serosal cultures All sterile before and after reduction The tips of the villi are sloughing and the villi are engorged with blood A fibrinous hemorrhagic membrane covers the mucosa The submucosa is tremendously edematous and hemorrhagic and infiltrated with round cells The longitudinal muscle is relatively normal The serosa (not shown) is edematous and hemorrhagic and infiltrated with a few polymorphonuclear leucocytes among the round cells

Plate I D RM 5 (X12) Experimental Intussusception in Dogs Intussusception of 56 hours duration Dog died at 56 hours of intussusception Autopsied at once The photomicrograph shows all three layers of this intussusception at the time of the animal's death

A Innermost layer of intussusceptum
B Returning layer of intussusceptum
C Ensheathing layer—the intussuscipiens

The changes are less extreme than in RM 23 (Plate II A) but one can see clearly the mucosal hemorrhage and ulceration and the submucosal hemorrhage in the returning layer (B) of the intussusceptum These changes are much farther advanced and much more striking than they are in the inner or entering layer of the intussusception The outermost layer the intussuscipiens is seen to be relatively normal

EXPERIMENTAL INTUSSUSCEPTION IN DOGS

Table of Results

Dog	*Duration of Invagination Hr*	*Culture Before Reduction*	*Result of Treatment*	*Culture After Reduction*	*Fate*
RM 16	18	Sterile	Reduced 1 enema	Sterile	Anesthetic death
RM 17	18	Sterile	Reduced 1 enema	Gram + cocci	Survived
RM 18	18	Sterile	Reduced 1 enema	Sterile	Survived
RM 21	18	Sterile	Reduced 1 enema	Sterile	Survived
RM 19	28	Sterile	Reduced 1 enema	Sterile	Survived Biopsied at 9 days
RM 20	28	Gram + cocci	Reduced 2 enemas	Gram + cocci	Survived Biopsied at 7 days
RM 22	28	Sterile	Reduced 1 enema	Sterile	Survived Biopsied at 2 days
RM 29	28	E coli	Reduced 3 enemas	E coli strep fecalis	Survived Biopsied at 10 days
RM 30	38	Sterile	Reduced 2 enemas	Strep fecalis	Survived Biopsied at 8 days
RM 31	38	Sterile	Reduced 3 enemas	Sterile	Survived Biopsied at 6 days
RM 33	38	E coli	Reduced 3 enemas	E coli	Survived Biopsied at 4 days
RM 36	38	Strep salivarius	Reduced 3 enemas	Proteus vulgaris strep salivarius *strep equinus*	Survived Biopsied at 2 days
RM 38	38	Sterile	Reduced 3 enemas	Gram—rods	Sacrificed immediately after biopsy
RM 24	48	— —	Spont reduction	Sterile	Survived
RM 25	48	— — —	Spont reduction	Sterile	Survived
RM 26	48	Gram + cocci	Irreducible	———	Chronic intussusception Survived Biopsied at 7 days
RM 23	48	Gram + cocci	Irreducible	— ——	Anesthetic death
RM 27	48	Gram + cocci	Irreducible	———	Died at 9[illegible] hours
RM 28	48	Gram + cocci	Irreducible	———	Chronic intussusception Sacrificed at 14 days
RM 32	48	Hemolytic Staph albus	Irreducible	———	Anesthetic death
RM 34	48	Salmonella Para B (post mortem)	No treatment	— ——	Died at 43 hours
RM 35	48	Strep fecalis E coli	Irreducible	— —— —	Died at 98 hours
RM 37	48	Cultures lost	Reduced 3 enemas	Cultures lost	Survived
RM 39	48	Strep fecalis E coli	No treatment	———	Died at 4[illegible] hours
RM 40	48	Clostridium welchii	Irreducible	——— —	Died at [illegible]3 hours
RM 41	48	Strep fecalis E coli	Irreducible	— ——	Died at 60 hours
RM 42	48	Strep salivarius	Irreducible	— ——	Died at 120 hours
RM 43	48	Strep salivarius E coli	Irreducible	——	Died at 141 hours

(From Ravitch and McCune *Bull Johns Hopkins Hosp 8* 1918)

Fig 16 Experimental Intussusception in Dogs. Intussusceptions were produced operatively under sterile conditions and the abdomens reopened under similar conditions at the stated intervals Cultures were taken of the serosal surfaces of the *intussuscipiens before reduction* and of the intussusceptum after reduction by hydrostatic pressure under direct visual control It is of greatest interest that pathogenic organisms were frequently found on the surface of the intussusceptum and even of the intussuscipiens in many animals with bowel sufficiently viable to survive even after full thickness biopsy of the bowel wall and closure of the defect.



Fig 17 RM 38 (X60) Experimental Intussusception in Dogs Intussusception of 38 hours duration reduced by enema and the dog sacrificed at once Cultures Before reduction—sterile after reduction—gram negative rod shaped bacilli In the gross the serosa was edematous and beefy The involved mucosa was darker than normal and sharply delineated Under the microscope one sees cellular infiltration of the well preserved mucosa Goblet cells are numerous Both muscle coats show severe changes seen most plainly in the circular muscle coat the viability of which is doubtful in some areas There is fibrin on the serosa Experience with animals allowed to survive would indicate that in the face of an intact mucosa and submucosa the areas of probable necrosis in the muscle layers could be expected to heal (From Ravitch and McCune *Bull Johns Hopkins Hosp* *82* 1948)

had courses much like the other fatal cases described above

It will be seen from Figure 16 a tabulation of our animal experiments that whenever an intussusception could be reduced by hydrostatic pressure the animal survived indefinitely (but for one which died under anesthesia) In no instance did any animal with a reduced intussusception have peritonitis abscess fistula or any other complication to suggest that non viable bowel might have been reduced In no instance did bowel reducible or irreducible rupture In the 18 28 and 38 hour periods the intussusceptions were all reducible and all dogs survived In 8 instances subsequent full thickness biopsy of the intussusception was performed and followed by uneventful recovery In the 48 hour group there were 13 dogs excluding two whose intussusceptions had reduced spontaneously Only 1 of these 13 intussusceptions at 48 hours was reducible by hydrostatic pressure This dog survived The other 12 were all irreducible by 3 feet of hydrostatic pressure and all 12 dogs died

The cultures taken from the serosal surfaces of the intussusceptions are of special interest and are shown in Figure 16 The following organisms were identified from these cultures often several from one animal *Escherichia coli* alpha Streptococcus fecalis alpha Streptococcus salivarius Clostridium welchii Proteus vulgaris alpha Streptococcus equinus hemolytic Staphylococcus albus and Salmonella para B As might be suspected while cultures were positive in 2 out of 3 dogs with intussusceptions 28 hours old or less 5 out of 6 of the 38 hour old intussusceptions yielded positive cultures and 12 out of 12 of the 48 hour old intussusceptions yielded posi



Fig 18 RM 33 (X60) Experimental Intussusception in Dogs Intussusception of 38 hours duration Reduced Biopsied after 4 days Cultures Before reduction—negative after reduction—Escherichia coli The mucosa is injected and hemorrhagic but the villi are tall Goblet cells predominate There is extensive submucosal infiltration and in this instance both inner and outer muscular coats show changes of moderate degree Changes in this animal s intestine are not as marked as in many others (From Ravitch and McCune *Bull Johns Hopkins Hosp 82* 1948)



Fig 19 RM 31 (X60) Experimental Intussusception in Dogs. Intussusception of 38 hours duration Reduced Biopsied after 6 days Cultures Negative The pathological changes are still striking hemorrhage and engorgement have regressed but there is a heavy cellular infiltration most marked in the thickened submucosa and in the subserosa Again goblet cells are prominent The internal circular muscle layer stains poorly is heavily infiltrated with round cells and appears degenerated The longitudinal muscle shows some cellular infiltration but the muscle fibers stand out sharply and the nuclei are well preserved (From Ravitch and McCune *Bull Johns Hopkins Hosp 82* 1948)

tive cultures These results were anticipated by D Arcy Power who suggested in 1897 that We do not yet know the exact course taken by the microorganisms as they pass through the wall of the bowel but there seems to be no doubt that microorganisms begin to traverse the intestinal wall when a loop of bowel has been constricted for a period of from 4 to 48 hours and that the more completely the blood supply is arrested the more rapidly they pass It is striking that bowel as well preserved as that seen in Figure 17 of RM 38 sacrificed immediately after ready reduction of a 38 hour old intussusception permitted bacteria to pass through the wall despite well preserved mucosa and submucosa The clinical significance of these bacteriologic findings is apparent They must account in part for the morbidity after operative reduction of intussusceptions particularly in the pre anti biotic era—high fever (sometimes seen also after non-operative reduction) abdominal abscesses wound infections postoperative adhesions with intestinal obstruction

Several features emerge from the pathologi

cal study of bowel recovering from intussusception In these experiments the returning limb is regularly found severely damaged even to the point of gangrene at a time when the bowel in the entering limb is still viable Under the conditions of our experiments and probably in intussusception beginning in the terminal ileum in patients the returning limb is cut off from its circulation by the acute kinking of the bowel as it turns on itself at the apex of the intussusception The pressure of edema should be the same on entering and returning layers but the circulation of the returning layer is further interfered with by the U turns made at the apex of the intussusception and at the neck effectively isolating this segment of bowel The frontispiece Figures 14 and 15 and Plate II A & B illustrate this point The changes caused by the condition are so severe as still plainly to be seen microscopically ten days after reduc



Fig 20 RM 20 (X60) Experimental Intussusception in Dogs Intussusception of 28 hours duration Reduced by enema Biopsied 7 days later Cultures Gram positive cocci before and after reduction In the gross the bowel was slightly thickened Under the microscope the villi are found engorged with blood and round cells and a few polymorphonuclear leucocytes *The mucosa is flattened* and the glands distorted The thickening of the bowel at this stage is due more to the tremendous cellular infiltration of the submucosa than to edema *The inner circular* muscle layer again appears glassy and infiltrated while the external longitudinal muscle layer is well preserved No ulceration is seen but the villi seem thinned out There is moderate serosal edema and round cell infiltration (From Ravitch and McCune *Bull Johns Hopkins Hosp* 82 1948)



Fig 21 RM 19 (X60) Experimental Intussusception in Dogs Intussusception of 28 hours duration Reduced Biopsied 9 days later Cultures All sterile The bowel appeared normal in the gross Under the microscope the epithelium is seen to have regenerated and appears normal but for increase in the number of goblet cells The villi *although irregular* are tall There is tremendous round cell infiltration of the submucosa and numerous engorged vessels. *There are a few polymorphonuclear leucocytes among the mononuclear cells.* The submucosal lymphoid follicles are greatly enlarged and contain a few polymorphonuclear cells. The serosa is thickened and *there are still a few round cells and plasma cells. The cir*cular muscle layer is still abnormal glassy and infiltrated with many round cells (From Ravitch and McCune *Bull Johns Hopkins Hosp* 82 1948)

tion (Fig 22 (RM 29)) Hemorrhage and engorgement disappear first then edema and lastly cellular infiltration The mucosa is frequently partially sloughed or eroded but ulcers through to the submucosa are not seen Despite this fact pathogenic bacteria make their way through to the serosal surface There is a striking difference between the survival ability of inner circular and outer longitudinal muscular coats as sharply demonstrated in the photomicrograph of RM 23 (Plate IIA) The inner circular muscular coat is largely destroyed and unrecognizable in the thickened returning layer of the intussusceptum while the outer longitudinal coat is relatively well preserved morphologically

Another avenue of investigation has been the study of the pressure tolerances of the human colon This was made necessary by such advice as that given by W E Forest of New York in



Fig 22 RM 29 (X60) Experimental Intussusception in Dogs Intussusception of 38 hours duration Reduced Biopsied 10 days later Culture Escherichia coli alpha Streptococcus fecalis. There is no more evidence of hemorrhage and engorgement One still sees an abnormal number of goblet cells There is some round cell infiltration of the submucosa The inner circular muscle is almost hyaline The outer coat shows some degenerative changes The serosa is thickened and infiltrated with round cells and polymorphonuclear cells and shows beginning organization Edema has entirely receded (From Ravitch and McCune *Bull Johns Hopkins Hosp* 82 1948)

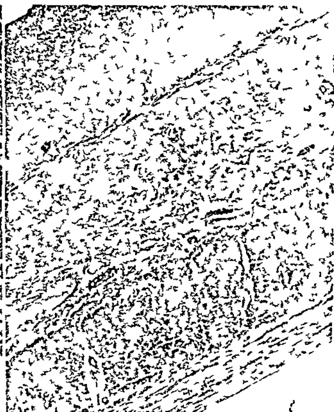


Fig 23 RM 23 (X60) Experimental Intussusception in Dogs Intussusception of 48 hours duration Irreducible Animal sacrificed and specimen obtained Serosal culture Gram positive cocci Only the returning layer of the intussusceptum the middle of the three layers of the intussusception is shown The bowel is almost entirely gangrenous. The mucosa is unrecognizable The submucosa is tremendously thickened The inner circular muscle is completely disorganized while the outer longitudinal layer is startlingly preserved in contrast to the general destruction of the other layer The serosa shows only edema The vessels do not show clots or thrombi A low power photomicrograph showing a cross section of the entire specimen is seen in Plate III A (From Ravitch and McCune *Bull Johns Hopkins Hosp* 82 1948)



Fig 21 RM 30 (X60) Experimental Intussusception in Dogs Intussusception of 38 hours duration Reduced Biopsied 8 days later Culture alpha Streptococcus fecalis The villi still show hemorrhage and an infiltration of mononuclear cells The submucosa is thickened and heavily infiltrated with round cells There is once more the usual difference between the muscle coats the outer being well preserved the inner not (From Ravitch and McCune *Bull Johns Hopkins Hosp* *82* 1948)

1889 He advised laying the child in the hall way inserting the enema tube and slowly ascending the stairs enema bag in hand exercising caution after ascending 10 feet !

Mortimer in England injected the colons of fresh cadavers with the ileo cecal valve ligated He found the serosa to begin to crack in some cases with five feet of pressure in most with eight feet and occasional rupture to occur with six feet of pressure Nordentoft performed similar experiments distending the bowel of dead newly born children with the ileum ligated at the ileo caecal junction The bodies had been dead from 13 to 51 hours Rupture of the bowel occurred with pressures of from three to ten meters In two cases in which the resistance of the small bowel was tested it was found to rupture after three and seven meters of pressure respectively

The 3 or 3½ feet of pressure used in patients would appear to provide a safe margin

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Chapter V

TREATMENT OF INTUSSUSCEPTION

A. OPERATIVE

The standard treatment of intussusception in this country and the British Isles, and in most of Europe, is immediate operative reduction of the intussusception. For a good many years great stress was laid upon the necessity for operating upon the patients within moments of their arrival in the hospital, and Doctor Ladd in particular emphasized the urgent importance of instant operation. As time has passed it has become generally accepted that the immediate need of a child with intussusception is for intravenous fluids or blood, for gastric aspiration as in any type of intestinal obstruction, and for the administration of antibiotics as in any other situation in which there is potential jeopardy of the vascular supply of the bowel. These measures having been undertaken, the abdomen is entered through the surgeon's incision of choice. Our own preference in intussusception, in a situation in which the operative manipulation may begin in the left lower quadrant and end in the right lower quadrant, would be for a lower midline incision. (Actually our intussusceptions are almost invariably reduced to the cecum by the barium enema in that 25% of cases in which enema reduction is not complete, and there a small McBurney incision suffices.) The intussusception is manually located, the bowel manipulated by compression just distal to the intussusception driving it proximally. If the bowel reduces easily and rapidly there is no need to deliver the intussusception, nor to question the viability of the bowel. The proper mechanism of manual reduction of an intussusception was clearly described by Hilton Fagge and Henry G. Howse of Guy's Hospital in their report in the Medical Chirurgical Transactions for 1876. They stated, "the intestine was accordingly drawn out *from the abdominal cavity, and ... even then* some difficulty was experienced in reducing it. Pulling at the end was quite ineffectual, though as much force as was considered justifiable was exerted in this way. Under a kind of kneading movement, however, combined with circular pressure upon the farthest intussuscepted part of the gut, it began to yield, and when once started the process went on readily until the last part of the intestine was reached."

It will be seen that this method of reduction, which is precisely that used today, is essentially one in which the surgeon, by compressing the bowel distal to the intussusceptum, increases the pressure within the lumen of that bowel, forcing the intussusception proximally in this manner. This pressure is applied much as in hydrostatic pressure reduction with an enema but the manual method of reduction is necessarily more traumatic. At times there may be encountered a substantial difficulty in operative reduction of an intussusception. In such instances it is important that the intussusception be delivered and carefully observed while pressure is being made distal to it. The first warning

of impending danger will be serosal cracking of the receiving loop of bowel as undue pressure is exerted upon it by the failure of the intussusceptum to yield At times the manipulation may be aided by the gentle injection of sterile mineral oil between the coats of the intussusception Attempts to stretch the neck of the intussusception with instruments invariably result in disaster and incision of the neck of the intussusception invites contamination of the operative field In any case it will be seldom that an intussusception so difficult of reduction as to require these strenuous methods will prove not to require resection because of gangrene or doubtful viability If therefore persistent and gentle compression of the bowel distal to the intussusception does not reduce the process resection should be undertaken One can tell in five minutes whether the bowel will reduce and stubborn persistence at manual disinvagination is to be decried

In view of the recognized incidence of recurrence of intussusception numerous methods have been undertaken by various surgeons to decrease the likelihood of recurrence In general it may be said that the various attempts at fixation of the cecum and of the terminal ileum have been abandoned as not being effective and as being potentially harmful A good deal has been written about the advisability or inadvisability of removal of the appendix at the time of reduction of an intussusception Although the group from the Children s Hospital in Boston formerly inveighed strongly against this practice a review of current writings on intussusception would suggest that appendectomy is now more commonly performed than not at the time of operative reduction In a review of our own material up to the time at which operative reduction became a rarity we found that patients in whom the appendix had been removed actually had a lower mortality than patients on whom appendectomy had not been performed No complications were attributable to appendectomy

Surprisingly enough there remains a substantial lack of agreement among the various surgeons interested in the problem as to the proper method of procedure when bowel is to be resected Intestinal resections and anastomosis of any kind were fraught with an almost prohibitive mortality up to the first decade of this century It is not surprising that in that day surgeons either refused to operate hoping that the gangrenous intussusceptum would pass spontaneously or attempted some minor appearing procedure rather than a bold resection and anastomosis Such a procedure was that of Cushing seen in Figure 25 This type of half way measure is still apparently performed from time to time but with as little success as it had in Cushing s day

Maunsell s method of resection of tumors of the bowel which was based on the deliberate production of an intussusception obviously suggested itself to those operating at the turn of the century and fearful of their ability to suture divided bowel after a resection This method is cited only for historical reasons since unlike most of the other methods of operation which have ever been proposed for intussusception (see Fig 26) it is now never used In this ingenious method the entering and receiving layers of the intussusception were sutured together at the neck of the intussusception The intussuscipiens was opened by a longitudinal incision and the intussusceptum amputated from within the intussuscipiens A circular suture of the amputated base of the intussusceptum was followed by closure of the incision in the intussuscipiens As might be supposed this method did not prove to be very successful despite its ingenuity

The drawings in Figure 26 illustrate the modes of treatment of irreducible intussusception which have been employed These are —

1 Resection of the bowel and creation of a double barrelled ileo colostomy

2 Exteriorization of the bowel with delayed division of the bowel (the Aseptic Mikulicz resection)

3 Primary resection with end to side ileo colostomy the open end of the colon being left as a vent

4 Side to side anastomosis around the intus

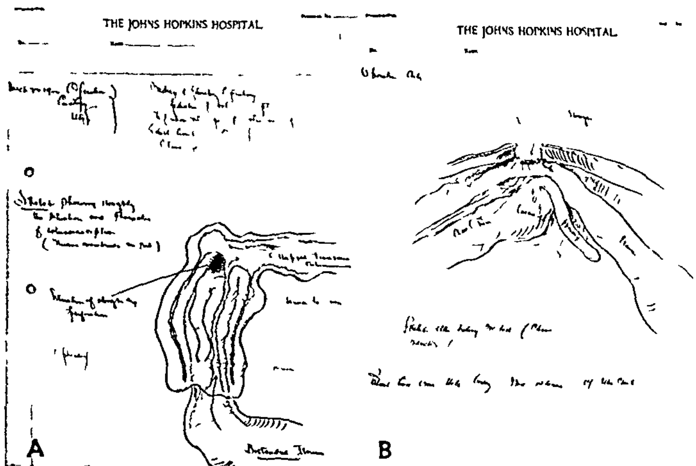


Fig. 25 Drawings by Harvey Cushing in History No. 10141 The Johns Hopkins Hospital
A Case of Intussusception

A March 22 1900

Operation Cushing Ether — Median Exploratory Laparotomy; Reduction of Intussusception; Perforation at apex of intussuscipiens; Establishment at this point of artif. anus; Chronic peritonitis

Sketch showing roughly the situation and character of intussusception (mucous membranes in red)	Collapsed transverse colon Serosa to serosa Lumen
Situation of slough and perforation	Distended Ileum
Appendix	

B Operation Cushing

Sketch illustrating method of closure after reduction of intussusception

Patient took anesthetic badly. Much shocked
Cf ether chart

Intussusception in the early days of the Johns Hopkins Hospital was a highly fatal disease despite the fact that Hutchinson had already demonstrated the feasibility of operation and Hirschsprung the lower mortality associated with systematic use of hydrostatic pressure. Harvey Cushing was all his life a meticulous and careful worker. The old histories of his patients contain many examples of careful and lucid illustrations like the present one.

How superior is a brief and nicely illustrated note (in two colors) like this to the impersonal formal typed operative notes which most of us leave today. The operation of course was poorly conceived. The bowel was too severely injured to be trusted beneath the abdominal wall. This patient failed to survive and the results of the employment of this procedure, which are still reported from time to time, have been similarly unsatisfactory. Cushing was sufficiently dissatisfied with his results in the treatment of intussusception that in 1906 when a child with hydrocephalus on whom he had attempted a subarachnoid peritoneal shunt through a metal tube developed intussusception, he advised observing the child in the hope that the intussusception would become gangrenous and would slough out spontaneously. In that instance this did not occur and the child succumbed.

susception which is left undisturbed

5 *Resection and primary anastomosis* side to side end to end or end to side

As the mortality of intussusception in general has decreased sharply and the frighteningly high mortality after resection of a few years ago has similarly decreased arguments favoring one or another method of treatment if based on mortality figures alone tend to lose their cogency

The most important determination to be made at operation is that the bowel is indeed non viable or that the intussusception is irreducible If after five minutes of attempts at manual reduction the bowel has not begun to move back one should assume that the intussusception is irreducible and proceed with some type of operation which recognizes this fact A good deal of experience is required to tell whether the beefy edematous thickened and indurated hemorrhagic bowel of a reduced intussusception is viable or not It is a striking fact that in institutions at which the majority of intussusceptions are reduced by barium enema the resection rate is far lower than in institutions where primary operative treatment is the rule It is entirely possible that the increased resection rate when operation is undertaken in all cases is occasioned to a considerable extent by the additional trauma to the bowel incurred as a result of the surgeon s manipulations Further *it seems probable that in a good many* cases bowel which is entirely viable has been mistakenly resected because of its swollen hemorrhagic appearance Two examples of the latter from our own experience have been cited and are illustrated in Plate IIC and D Needless to say if there is any doubt about the viability of bowel it must be resected although increasing experience will lead to greater accuracy in this determination There is at present no ready method for operating room determination of the viability of possibly compromised bowel

The choice of an operative method of treatment of an irreducible intussusception is swayed by the following factors

1 The desire to do as little as possible as rapidly as possible in a profoundly ill infant

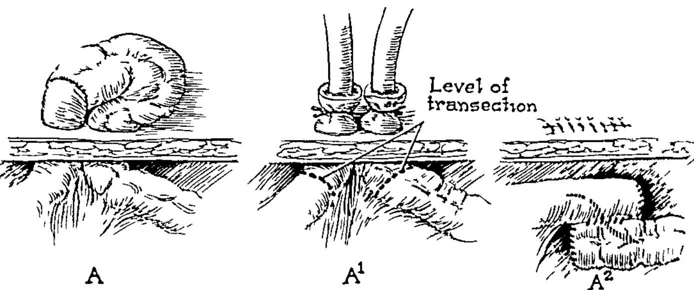
2 The desirability of avoiding the fluid losses and wound complications attendant upon creation of an ileostomy

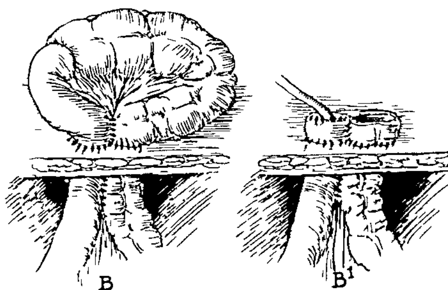
3 Desirability of immediate restoration of continuity of the alimentary canal and

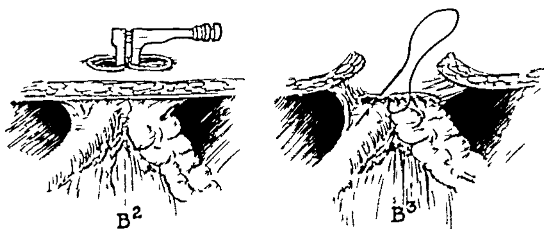
4 The avoidance of staged procedures

This is to a very considerable extent a matter of individual experience outlook and philosophy Those who have had disastrous results from attempting resection and primary anastomosis in these profoundly ill children with unprepared intestine and edematous bowel and probably contaminated peritoneal cavity are understandably prejudiced against such a procedure On the other hand as progress is made in surgery staged operations in one field after another have been given up for immediate definitive operative procedures For a long time of course it was thought that infants would not support an ileostomy with any degree of success Improved methods of management of fluid and electrolyte problems have very largely disposed of this objection to a staged procedure

Resection of the bowel in the course of the operation and bringing the bowel ends out through the wound (Fig 26A and B) is the most direct and simplest way of dealing with the problem Gross in Boston and Jones in Newcastle-on Tyne have described worthwhile modifications of this basic plan Gross (Fig 26B) divides *the* mesentery but does not resect the bowel The loops of bowel immediately proximal and distal to the anastomosis are sutured together in preparation for the construction of a double barrelled ileo-colostomy The abdominal wall is now closed about this doubled loop the intussusception itself being entirely exteriorized With the abdomen now completely closed the proximal and distal limbs are transected between clamps and a catheter is inserted into the proximal limb for decompression A crushing clamp is applied to the spur within a few days and the enterostomy is closed within six or seven days Gross reports 14 cases treated in this way with 11 recoveries a mortality of 23% Eleven of these patients were treated in the nine years between 1939 and 1948 with


Level of
transection
A
A1
A2


B
B1


B2
B3

recovery in ten and a mortality of 9% The ages of the successfully operated children range from three days to seven years Jones writing in 1953 reported 82 intussusceptions reduced by primary operation with no deaths six spontaneous reductions and six chronic intussusceptions operated upon with no deaths In addition there were nine instances in which resection was required The loop of involved bowel was brought out through the wound (Fig 26A) the bowel loops not being sutured together the abdomen was closed and the bowel resected Forty eight hours later the exteriorized ends of the bowel were resected and closed and a side to side anastomosis performed In these nine cases there was a single death He excluded from consideration a case in which the entire colon was necrotic and required resection with ultimate fatal outcome A later report by Court and Jones adds one more successful case

This method would appear to have all the advantages of Gross s method and to be moving much closer to the primary anastomosis since the reconstitution of the continuity of the bowel *is achieved in two days* The results could hardly be improved upon



Fig 26 Operative Treatment of Intussusception

A A1 and A2—The method of Jones of Newcastle

A—The entire intussusception is brought outside the abdomen the abdominal wound closed

A1—Both loops are amputated and tubes are tied into the bowel The dotted line indicates the site of proposed transection of the bowel the edematous exteriorized ends being removed 48 hours after the original operation and a side to-side anastomosis performed as in A2

Jones reports ten cases with a single death

B B1 B2 and B3—The Aseptic Mikulicz procedure of Gross

B—The entire intussusception is exteriorized the mesentery divided the afferent and the efferent limbs sutured together and the wound closed

B1—Both loops are amputated The proximal limb is decompressed by means of a catheter

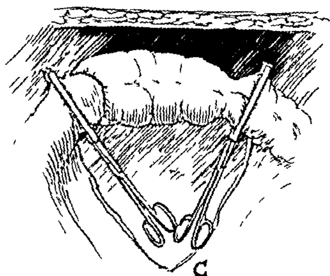
B2—Within a few days the spur is crushed by a clamp and on the sixth or seventh day the remaining enterostomy wound is closed by an essentially extra peritoneal operative procedure

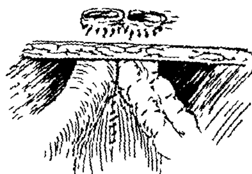
Gross reports 14 cases with 11 recoveries and of these in the years 1939 to 1948 eleven cases with ten recoveries.

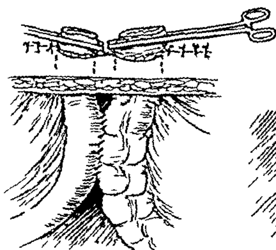
The chief advantage over primary anastomosis would appear to be in the improvement in the edematous state of the distended proximal bowel and in the certainty that after 48 hours any bowel apparently viable had survived the jeopardous period of progressing infarction

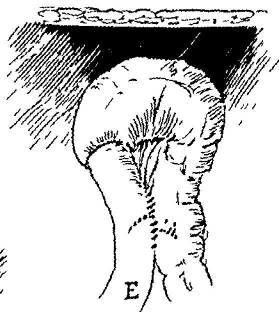
It is not surprising in consequence of the fact that the bowel which presents to view in an irreducible intussusception is almost always viable that surgeons have from time to time been tempted to perform anastomoses around the intussusception leaving it in situ Parry in 1909 and Rutherford in the same year reported successes by this method and Montgomery and Mussil in 1930 revived the method which is from time to time referred to as the Montgomery operation (Fig 26E) White and Dennison at the Royal Hospital for Sick Children in Glasgow are among the more recent advocates of this method In four of their cases a simple anastomosis was performed around the intussusception and all the bowel returned to the abdomen The subsequent courses of these children demonstrated that in two cases the intussusceptum *sloughed and was passed with satisfactory* function of the intestine from the time of operation In one case which subsequently died of leukemia and was autopsied the intussusception apparently remained in situ but recanalized In the 4th case the intussusception apparently reduced itself and a barium meal followed its normal route Dennison and some of the earlier authors in bypassing the intussusception advise suturing the neck of the intussusception to prevent its further advance

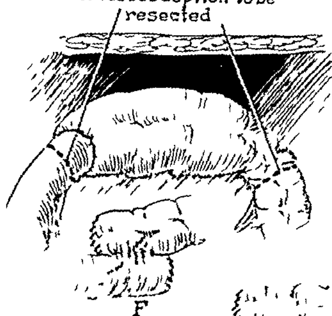
After Dennison s first report in 1948 White and Dennison in 1952 reported a total of 16 patients in whom a primary anastomosis was performed without resection of the mass In six of these the mass was exteriorized at the time because it was thought to be gangrenous through to the outer coat White and Dennison make the point that they have never seen death from peritonitis in unreduced intussusception and that death occurs from intestinal obstruction and toxemia For this reason they feel that the return of the irreducible mass into

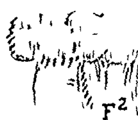














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the peritoneal cavity after a simple anastomosis does not violate surgical principles They also emphasize the fact that a substantial number of the resections are required not because of the basic extent of the pathological process at the time the patient is brought to the operating room but because of the damage inflicted by attempts at manual reduction Of their 16 cases four died Four of the six patients with exteriorized bowel required a subsequent hemicolectomy In one of the patients with exteriorized bowel the intussusception could be reduced subsequently and was returned into the abdomen with success In another such case the baby aspirated vomitus and died after the second small operative procedure on the second day The other three deaths were in children who had simple anastomoses and are described as having been due to bronchial pneumonia to shock and to toxemia respectively

In connection with the work of White and Dennison it is important to point out as Jones and others have stated that occasionally necrosis is found and recognized in the ensheathing layer and when this is the case quite obviously a simple short circuiting procedure cannot be performed Whether one would choose then as White and Dennison have chosen to perform an intra abdominal anastomosis with exteriorization of the bowel and of the intussusception without resection is a matter for individual judgment From the report of White and Dennison it seems that very little is gained by leaving this mass of bowel outside of the abdomen for a time It is of interest in White and Dennison s patients that after two months there was not in any case any radiologically demonstrable evidence that the short circuiting anastomosis was functioning and the implication is that the normal channel had been reconstituted and that the anastomosis had ceased to function Ones reaction is that this is an essentially unsurgical procedure and that one is loath to leave a potentially gangrenous lesion in place and that in general in intestinal surgery short circuiting intestinal operations which do not deal definitively with the primary lesion are unsatisfactory Unfortunately for such a priori judgments the method does work and the results are entirely acceptable It may prove that the risks of leaving the involved segment of bowel behind are no greater than the risks assumed in performing more complicated operative procedures and anastomoses

In order to combine the advantages of removal of the intussusception and restoration of the continuity of the intestinal tract in one stage with the decompressive benefits of the Mikulicz type of operation Woodhall (Fig 26D) at the suggestion of Dean Lewis resected the intussusceptum performing a side to side anastomosis bringing out the ends of the transected bowel as temporary vents This had the double advantage of decompressing the proximal intestine and minimizing the danger or consequence of leakage from an anastomosis in edematous bowel As the anastomosis began to function these vents closed spontaneously or could be

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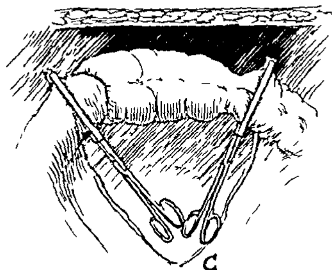
C and C1—Direct resection of the intussusception and performance of a straightforward double barrelled ileo colostomy

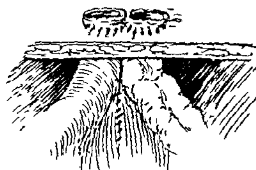
D—The method of Woodhall—the intussusception has been resected Continuity of the bowel has been restored by a side to side anastomosis and the ends of the bowel have been brought out as decompressing vents which will close spontaneously or can subsequently be closed by a few sutures

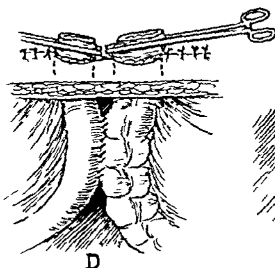
E—The procedure of Parry (1909) and of Rutherford (1909) revived by Montgomery (1930) and presently advocated by White and Dennison The intussusception is left in situ and a side to side anastomosis performed between the afferent and efferent loops White and Dennison report 16 cases with 4 deaths

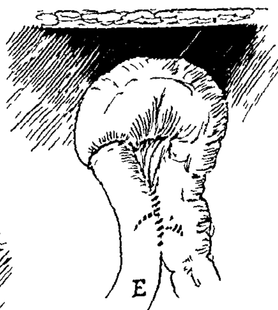
F F1 and F2—Resection and primary anastomosis either side to side (F) end to-end (F1) or end to side (F2) This is the most straightforward and definitive procedure This is the preferred method of Dennis of Benson and Sharp of Ladd and Allen of Zachary of Fox of Thatcher and others and seems to be becoming established as the procedure most frequently advocated and performed

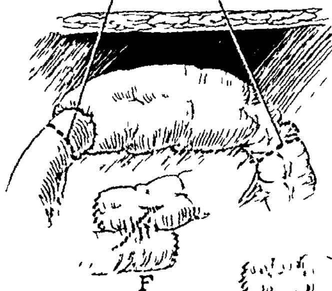
Mentioned only for the sake of historical completeness is Maunsell s operation Here the neck of the intussusception is sutured the intussuscipiens incised the intussusceptum amputated the transected edges of the intussusceptum and intussuscipiens whipped over and the incision in the intussuscipiens then closed

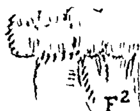


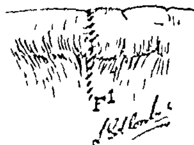












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closed by a small extra peritoneal operation

Finally there is the direct primary anastomosis (Fig 26F) usually end to end which most writers are coming to accept

In irreducible or strangulated intussusception it is self evident that a one stage resection and primary anastomosis would be the most desirable procedure if it could be safely *performed* That is actually the direction in which most surgeons reporting their experiences today are tending with the notable exceptions given above Our own experience with resection is essentially an old one and so few resections are now required on our service as to allow no conclusions Our present practice in bowel resection in infants for other causes is entirely in favor of a primary one stage anastomosis In a review of the entire material of The Johns Hopkins Hospital from 1889 to 1948 there were 32 operative procedures for gangrenous or irreducible *intussusception In nine instances the bowel was* resected and an immediate anastomosis performed Seven of these patients died the first one being in 1899 of a breakdown of the anastomosis Most of the deaths appeared to be of shock and infection and not due to a suture line breakdown with the exception of the case *done in 1899 In four cases the intussusception* was reduced and an enterostomy performed All four of these patients died In one case the bowel was extraperitonealized and the patient died In seven instances bowel of questionable viability was inverted in order to avoid the larger *operation of resection Three of these seven* patients died All three of these deaths occurred in the immediate post operative period and all were apparently due to the desperate condition of the patients at the time of operation Eight patients were treated by a Mikulicz type of resection one before 1930 with death seven since 1930 with one death Five of these were of the ordinary Mikulicz type and three of the eight were done by the modification described by Woodhall Again these two deaths occurred two to three hours after operation being apparently attributable to the condition of the child at the time of operation and to the operation and not to loss of fluids from the ileostomy The two patients operated upon by Woodhall both recovered as did a third child with a side to end anastomosis the end of the ileal segment being brought out as an ileostomy This fistula was closed seven days later

In the ten years January 1948 to January 1958 we have had 52 intussusceptions at The Johns Hopkins Hospital and no deaths Of these only two had bowel resections one in 1949 in a seven month old infant for an enteric cyst at the ileo caecal valve which had caused a reducible intussusception and one in 1957 in an infant of four months with an irreducible intussusception reaching to the hepatic flexure (Fig 27) Primary resection and anastomosis was performed in both infants without event

The reported mortality of intussusception in those cases which required resection has been extremely high until very recently and it is small wonder that surgeons have shied away from primary anastomoses believing that these required larger operations and longer procedures in extremely sick children Benson and Sharp reporting their experience at The Children s *Hospital of Michigan* in 1950 reported five children with intussusception resected during the previous three and a half years with primary anastomosis and a single death due to necrosis and leakage at the suture line Some of their anastomoses were end to end some end to side some side to side The fatal case had a side to side anastomosis *They feel that side to* side anastomosis is preferable for infants younger than four months after which age the size of the bowel begins to make end to end anastomosis feasible and practical Dennis writing from the University of Minnesota reported eight resections for intussusception between 1940 and 1947 with primary end to end anastomosis using the closed technique He had no deaths Packard and Allen writing from The Denver Children s *Hospital report nine resections* for intussusception with no deaths Primary anas

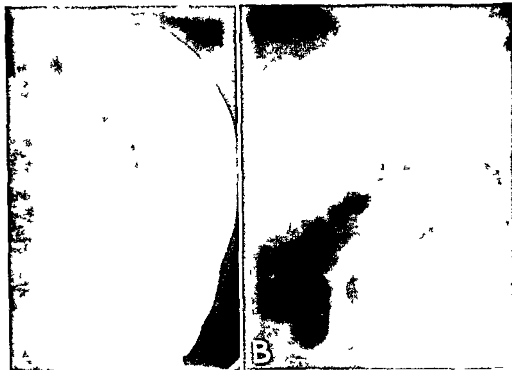




Fig 27 Incomplete Barium Enema Reduction Resection of Intussusception End-to-end Anastomosis K. K. Female 5 months old Intussusception 24 hours duration

A The barium column stops abruptly just proximal to the splenic flexure There is a vague filling defect

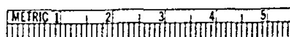
B The intussusception has been reduced across the mid line This is an occasional case in which barium seems to enter a short distance into the lumen of the intussusceptum producing a conical barium shadow

C & D The intussusception was reduced into the ascending colon and could be reduced no further Note the almost completely transverse cut-off of the barium column The complete absence of barium between the layers of the intussusception suggests a tight and irreducible intussusception In fact operation undertaken at this point revealed an intussusception which resisted attempts at manual reduction

(Continued on next page)



E





F

Fig. ?? (Cont.)

tomosis was performed in all There is no difficulty in finding reports usually somewhat earlier than these listing prohibitively high mortalities from resection for intussusception Snyder Kraus and Chaffin writing from Los Angeles Children s Hospital in 1949 report a 66% mortality in patients requiring resection Gibbs and Sutton in 1943 reported a 71% mortality in patients requiring resection In their hands resection and primary anastomosis yielded a mortality of 43% whereas Mikulicz resection produced a 100% mortality Gibson and associates reporting from the Mayo Clinic in 1949 had a mortality of 50% in patients requiring resection and primary anastomosis and had one survival after a Mikulicz resection Hogg and Donovan from Babies Hospital in New York in 1946 reported nine resections for intussusception Three out of five with primary resection and anastomosis succumbed and two out of the four with Mikulicz resection died McLaughlin in 1948 reported resection in 21 cases with a mortality of 50% Gross and Ware writing in 1948 reported 18 cases with primary resection and lateral anastomosis with only three recoveries a mortality of 83% These had all been performed more than ten years before the report and these results were the basis for the abandonment of primary resection and anastomosis at the Children s Hospital in Boston In 1953 Gross had performed 18 Mikulicz operations by the technique described above and had fifteen recoveries

Lawrence and Ulfelder reported from the Massachusetts General Hospital in 1952 five resections with anastomosis for irreducible intussusception with one death

Zachary prefers a generous resection with end to end anastomosis by a closed technique and decries either the aseptic Mikulicz procedure other Mikulicz procedure or the addition of a lateral anastomosis to such a procedure according to the method used at Newcastle on Tyne

Fox in 1956 from the Children s Memorial Hospital in Chicago reported ten resections with primary anastomosis and one death

Thatcher reporting from the Milwaukee Children s Hospital in 1954 reported 15 resections with primary anastomosis since 1947 with one death a 6 6% mortality

In no single series is the number of resections required sufficiently large to make a comparison of result statistically significant In the small series of resections with which we thus have to deal random sampling of a few more profoundly ill patients in one clinic than in another may seriously color the results It would appear probable that as good results can be obtained by primary resection and anastomosis as by a Mikulicz exteriorization procedure It certainly appears to be established that if a Mikulicz procedure is to be performed an anastomosis may be performed at the same time by the method of Woodhall leaving one or both loops of bowel open as a vent or the double barrelled ileostomy may be taken down after 48 hours and the exteriorized ends resected and an anastomosis performed by the method of Jones or a double barrelled ileocolostomy may be performed the spur crushed and the bowel anastomosed some time later—the method of Gross

All of these methods are appreciably less tidy than a direct anastomosis and seem not to produce demonstrably better results It is to be expected that there will be a gradual trend towards general adoption of the one stage definitive procedure The short circuiting procedure presently advocated by the Glasgow group also

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E The intact specimen the ileum entering the intussusception at the left

F The specimen has been split and the view is that of the interior of the portion visible in E which has now been turned over so that the intussuscipiens is at the left and the entering ileum at the right Notice the apparent good condition of the proximal ileum and the tremendous thickening of all coats of the returning limb of the intussusceptum and the beginning slough of the mucosa The intussuscipiens is distended and thinned out but intact The appendix also visible in E has just begun to be drawn into the intussusception and its distal portion shows changes in color

An end-to-end anastomosis was performed The child recovered uneventfully and left the hospital in ten days

represents a less than definitive operation which does not have the appeal of the primary resection and anastomosis nor results sufficiently better than reported by the other methods to warrant its adoption.

Above all it must be stressed that children with intussusception are sick individuals, that they are suffering from substantial fluid loss, loss of electrolytes and blood into the lumen of the bowel, into the bowel wall and into the peritoneal cavity even before operation has been undertaken and that bacterial transmigration through the bowel wall begins even in a stage when the bowel is still viable. No operative method will yield good results if time is not taken first for swift and efficient attention to correcting and counteracting these factors. No child with intussusception should be operated upon without having at least received intravenous fluids and any child who is at all prostrated should receive blood. This should be in the amount of 15 cc per kilogram of body weight. If blood has not been administered and operation discloses the need for resection blood transfusion should be begun at once, all patients having been matched for transfusion in any case. All such children should be operated upon with an intravenous drip running. As in all operations for intestinal obstruction, most particularly in infants who strangle so readily on vomitus, the stomach should be emptied by stomach tube before operation is begun and suction maintained on the gastric catheter throughout the operation. Antibiotic administration should be begun before the child is taken to the operating room. This serves to counteract the effect of the bacterial invasion caused by the primary condition, the potential soiling at operation and possible pulmonary infection. In the fast moving field of antimicrobial therapy specific recommendations are likely to have only a fleeting validity. Our present preference is for a combination of penicillin and streptomycin.

Post-Operative Therapy

Treatment after operation is guided essentially by the same indices in the child who has had a simple operative reduction of an intussusception and the child who has had a resection. Gastric suction is maintained from the time of operation and the child treated as if he had an established intestinal obstruction. As soon as the child has passed a stool the suction is discontinued and the child begun on oral feeding. In the simple reduction of an intussusception this will usually be within 24 hours. After resection it may be a matter of several days. At all events nothing is given by mouth until the child has demonstrated by the passage of stool that the intestinal canal is open and functioning. Until this time the fluid balance is maintained by the administration of intravenous fluids to the amount of 100 to 150 cc per kilogram of body weight per day. We prefer a lactate saline glucose solution for ordinary purposes. This consists of one part M/6 lactate, two parts 0.85% NaCl and three parts 5% glucose in water. In profoundly ill children with resections and severe fluid losses it may be well to add potassium chloride 1.5gms/1000 cc of solution. Blood may occasionally be needed in the post-operative period in children who have had a resection.

B Non Operative

The first successful operative reduction of intussusception in an infant was reported by Jonathan Hutchinson in 1873, the patient having been operated upon in 1871. Until this time the disease had been treated either expectantly, waiting for gangrene of the intussusception and spontaneous passage of the slough, or had been treated by rectal instillations.

The method of treatment by rectal instillations is older than any operative one. Hippocrates and Praxagoras advised forced injection of water or air into the intestines in all forms of ileus without having described intussusception and a number of authors in the early nineteenth century advised and used clysters successfully for intussusception. Others used bellows or connected hydrogen generators with the rectum or inserted effervescent powders into the rectum or inverted bottles of charged water injecting carbon dioxide under pressure. Still oth

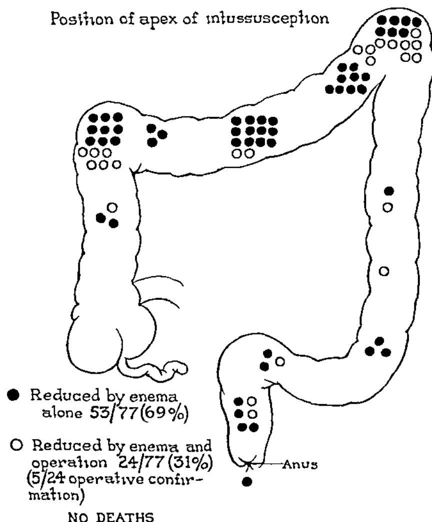


Fig. 28. Seventy-seven Cases of Intussusception Treated Primarily by Barium Enema at the Johns Hopkins Hospital 1939-1957 Inclusive. Note that the position of the intussusception when encountered by the barium enema has little or nothing to do with reducibility. Of those cases operated upon, five were found to have had their intussusceptions completely reduced by the barium enema, so that the barium enema reduced 58/77 or 75%. Of the 19 others operated upon, in all but one the barium enema had reduced the intussusception to the caecum.

ers passed long bougies in the attempt to perform a direct reduction, or stimulated the prolapsed intussusceptum with electricity, or tried to shrink it with cold water or hypertonic saline solution. With this background Hirschsprung of Copenhagen in 1876 reported his experiences with the systematic treatment of intussusception in infants and children by hydrostatic pressure. By 1905 Hirschsprung was able to report on 107 personal cases of intussusception. His results were so superior to any previously reported that his contemporaries seem to have doubted his conclusions. He appears to have been forced in self defense to publish a concise account of each of his 107 cases. He presented a 35% mortality in a disease which up to that time was fatal in over 80% of the cases. In 81 patients treated by Hirschsprung with enema alone the mortality was 23%. These figures compare favorably with those from The Johns Hopkins Hospital, using operative treatment only, in the period from 1929 to 1938, more

than 25 years after Hirschsprung. The method of reduction by hydrostatic pressure was systematized *by the Danish school Hirschsprung* and his successors Koch and Oerum and Monrad. All of these practiced to varying degrees, manual disinvagination of the intussusception *through the* intact abdominal wall. In 1913 and 1914 the first reports of intussusception diag*nosed by* roentgenography were made by Ladd and by Lehmann. In 1927 Olsson and Pallin in Sweden, *Stephens* and Retan in the United States and Pouliquen in France all reported reductions of intussusception by barium enema under fluoroscopic control. Clubbe of Sydney, the great Australian student of intussusception, while favoring operative reduction of intussusception in his early cases used an injection of warm oil maintaining that "it always reduces the intussusception to a certain extent and in the best and gentlest possible way. In this way it lessens the shock of the coming operation because less manipulation of the intestines is needed. It is especially useful in cases in which we find the intussusception in the rectum because if we do not use it we may find some difficulty in getting our fingers below the tumor to begin the squeezing process." Hipsley, also of Sydney, Australia, dissatisfied with a mortality of 8% with the operative treatment of intussusception began the regular treatment of intussusception by hydrostatic pressure with normal saline solution. In 1926 Hipsley reported his first series of 100 cases so treated, with the spectacularly low mortality rate for that time of 5%. Since that time use of saline enemas has continued to be standard in a number of Australian clinics but the use of barium enema has been popular in Scandinavia and in South America. In this country and in England and Germany the use of hydrostatic pressure has never been widely accepted although in recent years there have been noticeable some concessions in its direction by those who previously resorted solely to operation.

The addition to hydrostatic pressure reduction of manipulation through the intact abdominal wall has been noted in Copenhagen and elsewhere to result in occasional rupture of the bowel and for this reason that is to be strongly *condemned.* Our own experience with hydrostatic pressure has been limited entirely *to the use of the barium* enema reduction and dates from 1939. From 1939 to 1946 *the use of the* barium enema became increasingly the method of choice in the treatment of intussusception at The Johns Hopkins Hospital and since 1946 it has been universally the method of choice. The demonstration that during the period 1939 to 1947 there were 21 primary operative reductions with five deaths, a mortality of 21%, and 27 primary enema reductions with no mortality had a good deal to do with influencing the practice of the surgical service. Prior to that time selection of method depended upon my personal success in persuading the individual surgeon in charge of a given case. Since that time it has been standard practice to institute barium enema in all cases suspected of having intussusception. The Johns Hopkins series consists of 77 cases of intussusception in infants and children treated primarily by barium enema from 1939 to 1958. We have had no deaths in the series. During the three years 1952–1955 at the Mount Sinai Hospital in New York, when barium enema reduction of intussusception was the method of choice, there was a single death. This was in a child in whom the intussusception could not be reduced by barium enema and in whom operation was resorted to without delay. It is apparent from the record that the intussusception was reduced with some difficulty at operation and that non viable bowel was judged to be *viable* and left behind. The patient's condition steadily worsened and the patient *died without reoperation.* At autopsy the bowel which had been involved *in the intussusception* was found frankly necrotic. At the Baltimore City Hospitals where barium *enema reduction of* intussusception is now standard practice, we have also had one *death in a child* treated by enema primarily. This was a marantic infant six weeks *of age who had had diarrhoea* with some bleeding for most of its brief life and who had been sent to the City Hospitals in a moribund state

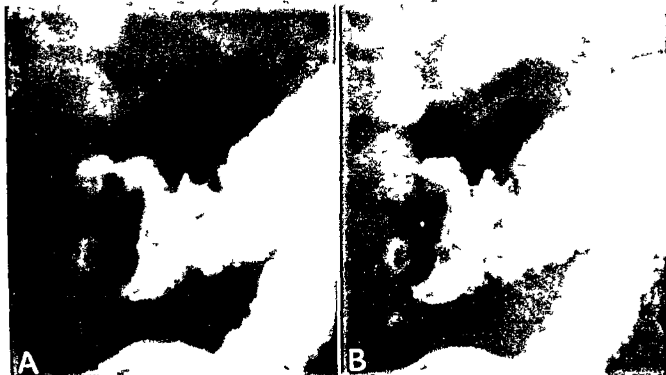


Fig 29 Reduction by Barium Enema Alone M J Female sixteen months old This infant awakened at 4 00 a m crying with pain drawing up her legs and began passing bloody stools shortly afterwards at the same time that she began to vomit Seen nineteen hours after the onset she was vigorous not prostrated There was resistance in the right upper quadrant where a sausage shaped mass could be felt extending across the epigastrium There was bloody mucus in the rectum

A Shows the intussusceptum encountered in the transverse colon to the left of the vertebral column The meniscoid e fect produced by the filling defect of the intussusceptum and the extension of the horns of the meniscus up into the space between the intussusceptum and the intussuscipiens are beautifully shown

B The intussusception has begun its reduction and has been displaced almost to the vertebral column

(Continued on next page)

It had diarrhoea distention tracheo bronchitis and bilateral pneumonia Despite the continuing diarrhoea after two days because there was a good deal of blood in the stools a barium enema was advised This was interpreted as showing no intussusception The review of the films showed poor filling of about three inches of the small bowel and an intussusception originally present in the colon (Fig 11) Operation was undertaken at once No intussusception was found An annular cyanotic mark thought probably to have been caused by the neck of an intussusception was found about two feet above the ileo cecal valve There was no hemorrhage or edema

The baby continued in its marantic and moribund state and died two days later This intussusception was almost agonal in an infant already moribund and was so rapidly reduced that the original observers doubted its existence Autopsy showed an extensive and severe enteritis involving all the intestine as well as a severe bilateral pneumonia and a diffuse tracheo bronchitis

Technique of Barium Enema Reduction

As soon as the diagnosis of intussusception is suspected the operating room is notified and the patient formally posted for operation In most cases the intussusception has been reduced before the operating room has had time to send for the patient Intravenous fluid administration is begun at once in almost all children As in any type of intestinal obstruction the stomach is emptied and the gastric tube left

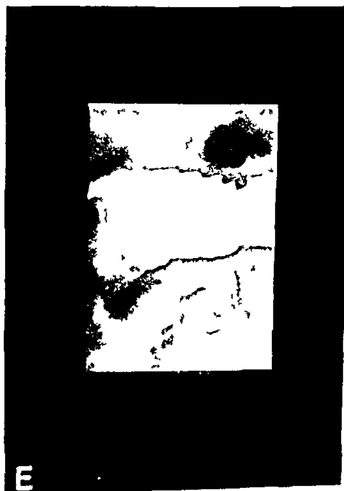




Fig. 9 (Cont.)

C The concave filling defect has almost disappeared as the intussusception has moved across the vertebral column and

D The meniscus is re-forming once more to the right of the vertebral column





E The intussusception has been reduced almost to the hepatic flexure and the meniscus is re-forming once more

F The barium has passed beyond the hepatic flexure and in

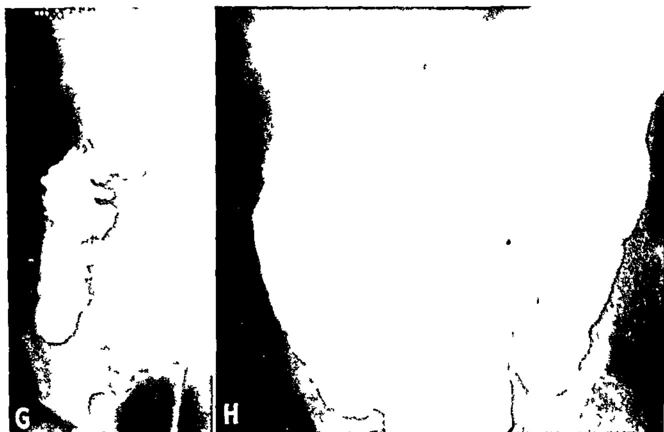


Fig 9 (Cont)

G Begins to fill the ascending colon but no barium is seen in the ileum and the cecum is certainly not completely filled

H The abdomen is so completely obscured by barium that it might be difficult to be certain that there were loops of small bowel which had been filled With a little care actually one loop of small bowel can be seen lateral to the mid ascending colon and several loops of small bowel can be seen immediately beneath the middle of the transverse colon

in place Although it has not occurred in our experience the vomiting and aspiration of vomitus by an infant in the dark of the fluoroscopic room which might otherwise occur could pose a serious problem In the more severely shocked children blood is matched and blood transfusions begun actually in the fluoroscopic room An ungreased 45 cc Foley bag catheter is inserted into the rectum the balloon inflated fully and the buttocks strapped tightly together with adhesive It is remarkable to see how large a balloon a tiny infant can expel if it struggles The catheter is connected to an ample reservoir of barium at a height of between three feet and three feet six inches above the table We do not employ anesthesia or sedation In a single instance the patient was a six year old girl who bit the author as the manipulation was begun In this instance upon mature reflection it was decided to use general anesthesia The barium is permitted to run into the rectum uninterruptedly although at times the flow may be momentarily halted while spot films are exposed The barium will usually be seen to run rapidly into the rectum and colon until the head of the barium column meets the point of the intussusception At this point the rounded head of the advancing barium column suddenly becomes concave forming a meniscus round the head of the intussusception much as would a column of barium in the vagina outlining the cervix For purposes of documentation we usually obtain a film of the intussusception when first encountered and at least one more to show complete reduction As the hydrostatic pressure of the column of barium suspen

I

J

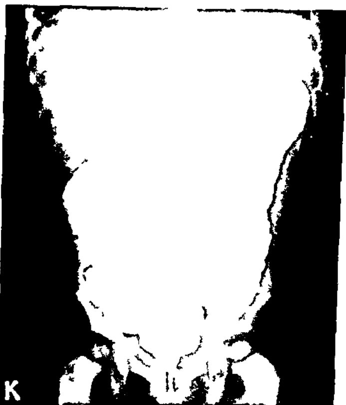


Fig. 29 (Cont.)

I, J, K show that with progressive evacuation of the barium after the balloon catheter has been removed (J and K), barium filled loops of small bowel can be more clearly and conclusively demonstrated.

The entire process of reduction required ten minutes. The child left the hospital well in three days. Charcoal installed in the stomach immediately after the barium enema reduction was recovered in the stool within six hours.



Fig 30 Reduction by Barium Enema Alone P C Female 3¾ years old This child entered the hospital 14 hours after the onset of abdominal pain and vomiting She had vomited repeatedly no stool had been passed She was prostrated and listless dehydrated with markedly sunken eyes the odor of acetone on her breath and three plus acetone in her urine The abdomen was soft and a transverse sausage shaped mass was visible and palpable in the epigastrium measuring about 8 x 3 centimeters and firm in consistency On barium enema the intussusception was met to the left side of the transverse colon and readily reduced with free filling of the ileum within 15 minutes

A The characteristic filling defect in the head of the barium column is seen just proximal to the splenic flexure

B The meniscus is found flattened as the barium reduces it to the right of the vertebral column

sion is maintained the meniscus lengthens the horns extending proximally around the intussusceptum until suddenly the intussusception is displaced and the meniscus flattens out again This process is repeated sometimes with extreme rapidity until the intussusception is reduced to the cecum and through the ileo cecal valve In the transverse and ascending colon the intussusception frequently fits loosely enough in the larger caliber intussuscipiens so that barium seeps between the intussusceptum and the intussuscipiens producing the coiled spring appearance even in acute intussusceptions One should take care to see that the barium flows freely into the ileum If the ileum does not fill freely one should operate at once even though the intussusception has apparently been reduced through the ileo cecal valve and the cecum fills without any defect Little harm is done by a McBurney incision which discloses that the intussusception has been in fact completely reduced and real harm may result if complete reduction of intussusception is incorrectly diagnosed At times when an intussusception rests entirely within the small bowel it can be demonstrated by barium refluxing through the ileo cecal valve up to the intussusceptum (Fig 10) This is not dependable and in any case one makes no attempt to reduce intussusceptions at this level by barium enema

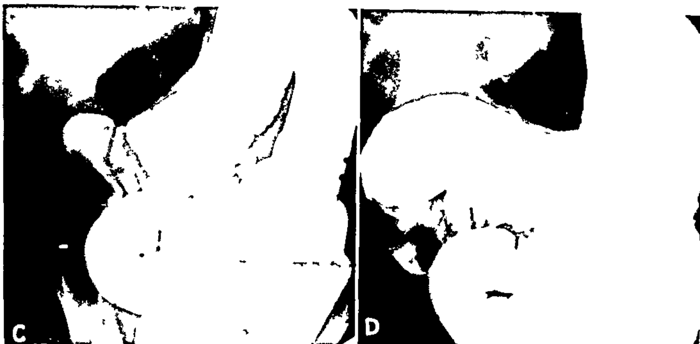
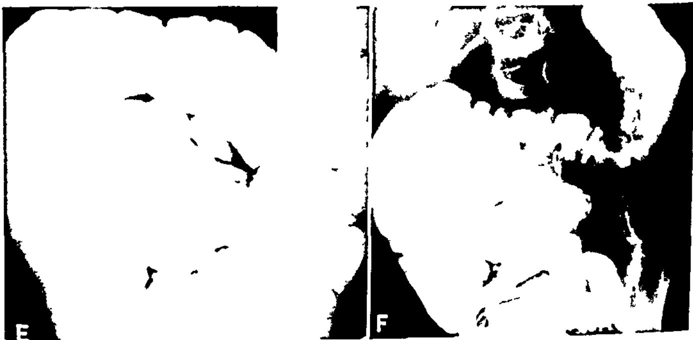


Fig 30 (Cont)

C Barium has reached the hepatic flexure between the intussuscipiens and the intussusceptum although the latter is still almost at the right vertebral border

D Shows the hepatic flexure filled and barium seeping between the intussusceptum and the larger caliber ascending colon



E Shows free filling of many loops of small bowel
When the barium was expelled the returns were colored pink by blood

F A film taken with the colon less distended after partial expulsion of the barium permits easier differentiation between the large bowel and the small bowel framed by the partially emptied colon
The child passed a spontaneous stool and flatus within 6 hours and was discharged well on the 5th day



Fig 31 Reduction by Barium Enema Alone C G Female 6 months old This child was brought to the hospital 65 hours after the onset of abdominal pain and vomiting She had been passing bloody mucus for 6 hours before admission A large tubular mass was felt in the left side of the abdomen and thought to be the intussusception The child s general condition was good Administration of intravenous glucose and saline was begun and a barium enema undertaken A catheter was placed in the stomach as in all these patients to prevent vomiting and aspiration in the dark of the fluoroscopy room A balloon catheter was inserted into the rectum and distended

A The plain film shows the gastric catheter in place and the rectal balloon inflated A number of dilated loops of small bowel are seen in the left upper quadrant

B Demonstrates the barium outlining the end of the intussusceptum in the rectum immediately above the balloon although we had not felt the intussusceptum on rectal examination *(Continued on next page)*

Intussusceptions entirely limited to the small bowel will usually present the picture of intestinal obstruction and in such patients if barium enema shows no intussusception in the colon operation should be undertaken at once

There is great variation in the speed with which reduction can be achieved In one infant with an intussusception of the transverse colon motion pictures were taken of the entire reduction The continuous film strip covers a period of less than five seconds In another instance an experienced pediatrician called to say he was sending in an infant with intussusception All was made ready the baby was met at the door the intussusception which was encountered at the mid transverse colon was completely reduced in two to three minutes and the baby was on his way to the ward within ten minutes of the time he passed through the hospital gate At other times reduction may be extremely stubborn

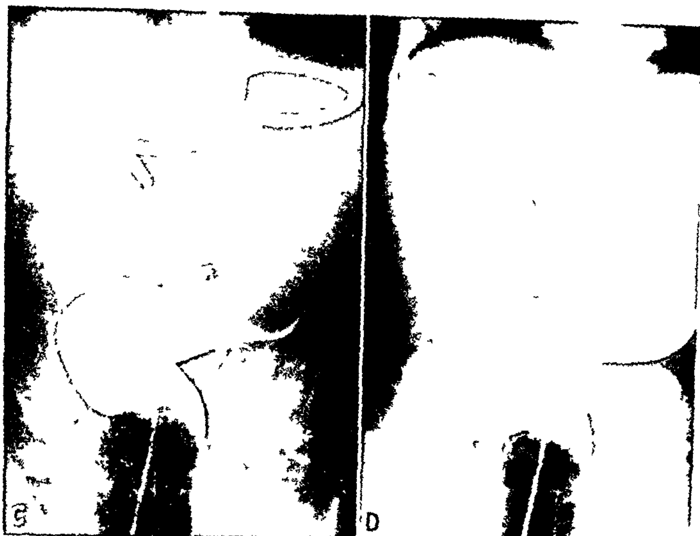


Fig. 31 (Cont.)

C. The intussusceptum has been reduced to the sigmoid and there is a sharp meniscoid edge to the advancing barium column. When the intussusceptum fits the intussuscipiens tightly very little barium is able to ascend between the two loops and one gets a meniscus of this character. When the fit is less snug a good deal of barium may pass between the loops producing the coiled spring appearance as the barium concentrates between the edematous folds of bowel at the same time that the end of the intussusceptum produces a large round filling defect. Frequently the meniscoid shadow is seen in the left colon and as the intussusceptum is reduced the radiologic picture of the intussusception changes toward the right colon.

D. The intussusception has been reduced well up into the descending colon. (Continued on next page)

Not rarely there will be a momentary pause when the intussusception is encountered then steady reduction to the splenic flexure. Delay at the splenic flexure may be followed by rapid reduction to the hepatic flexure where there may again be some delay. Filling of the cecum is often slow and the cecum may distend quite markedly before a sudden rush of barium into the small bowel denotes complete reduction.

We have no hesitation in continuing with the reduction for as long as 15 minutes or an hour so long as steady progress has been made. The children are receiving intravenous fluids or blood as needed during the procedure and the roentgen exposure is only fractional and intermittent. Once it is obvious that there has been an absolute arrest of the barium column for ten minutes or so nothing is to be gained by persisting and operation should be proceeded with.

The principal difficulties in the use of this



Fig 31 (Cont)

E The reduction has progressed around the bend of the splenic flexure

F Although the barium has reached the right colon and the filling defect of the original intussusception is still seen in the ascending colon there is an abnormality in the left transverse colon Inspection shows the column of barium going through the middle of another intussusceptum and outlining a colo-colic intussusception which is only incompletely reduced

method are likely to involve a leakage of barium from the rectum because of failure to strap the buttocks together tightly or plugging of the tubing or catheter by lumpy barium mixture If there is any doubt that there has been a free flow of barium into the bowel with maintained pressure the child may be allowed to evacuate and the procedure repeated

It is our present practice to rely in general upon one continuous sustained injection The intussusception if not completely reduced is almost invariably reduced to the cecum although in a few cases, it has gone no further than the ascending colon and in the last case treated the intussusception which proved at operation to be irreducible could not be reduced by the barium enema beyond the hepatic flexure

It is of the utmost importance to be certain that there is free filling of many loops of small bowel with barium The distended cecum and the sigmoid if redundant may overlap and between them obscure the field so that it is difficult to see the ileum In such instances if the child is turned upon the abdomen its own weight may separate these two loops of bowel and permit one to see the ileum between them





Fig 31 (Cont)

G This intussusception is still further reduced while the transverse colon is filling and one sees the original intussusception more sharply in the ascending colon The position of the meniscus of the colo-colic intussusception in F and G is such as to suggest that this second intussusception was actually a retrograde intussusception

H The colo colic intussusception is completely reduced and the ascending colon progressively fills with barium

Under no circumstances do we ever manipulate the abdomen however great the temptation Under no circumstances do we raise the cannister of barium higher than three feet six inches above the table Neglect of these precautions invites rupture of bowel or reduction of gangrenous bowel as a number of reports testify

If the abdomen becomes so distended with barium that it is difficult or impossible to be certain that loops of small bowel have filled the catheter is removed the child allowed to evacuate and then fluoroscoped once more The loops of small bowel filled with barium will usually be seen framed by the colon Immediately after the completion of the reduction powdered charcoal is deposited in the patient's stomach through the tube already in place Six hours later an enema is administered to recover the charcoal and prove beyond doubt the relief of obstruction This method introduced by Hipsley assures one that the obstruction has been relieved but does not necessarily demonstrate that the intussusception has been totally reduced Hipsley making use of the observation that fluid which refluxes into the ileum will not be promptly expelled measures *the girth of* the children before and after a saline enema If the abdominal girth remains substantially

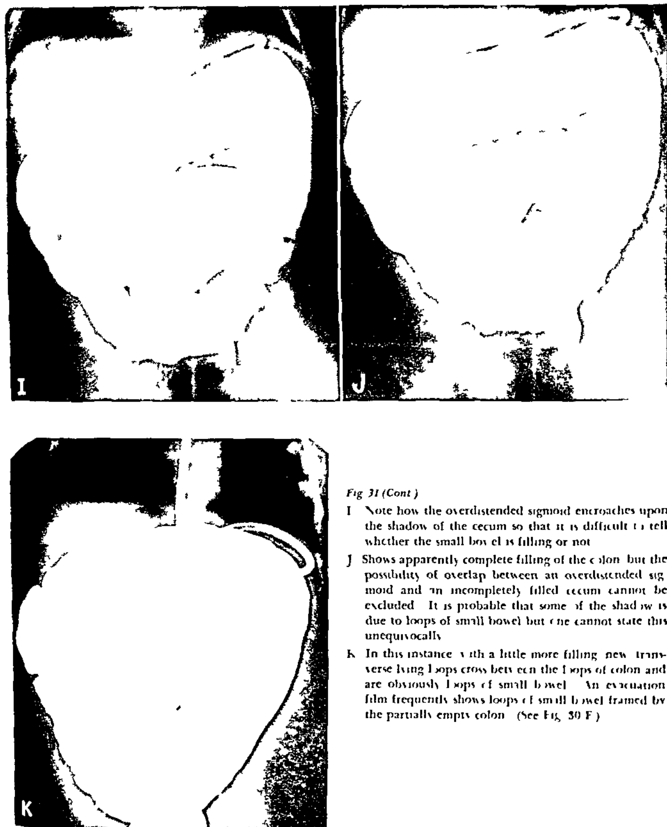


Fig 31 (Cont)

I Note how the overdistended sigmoid encroaches upon the shadow of the cecum so that it is difficult to tell whether the small bowel is filling or not

J Shows apparently complete filling of the colon but the possibility of overlap between an overdistended sigmoid and an incompletely filled cecum cannot be excluded It is probable that some of the shadow is due to loops of small bowel but one cannot state this unequivocally

K In this instance with a little more filling new transverse lying loops cross between the loops of colon and are obviously loops of small bowel An evacuation film frequently shows loops of small bowel framed by the partially empty colon (See Fig 30 F)

increased after expulsion of the enema he accepts this as evidence of free passage of the fluid into the ileum and hence of reduction of the intussusception While his results have been extraordinarily good we prefer the certainty of direct fluoroscopic observation and the opportunity that this affords for objective documentation on the film of the existence of an intussusception and of its reduction

The successful reduction of an intussusception is indicated by the following criteria —

1 *The free flow of barium well into the small bowel* This is the sine qua non of complete reduction and must be insisted upon in all cases which are not to have an immediate operation The remaining criteria are merely confirmatory

2 *The return of the barium with feces or with flatus* This is not helpful in the occasional child who is incompletely obstructed but most children with intussusception are completely obstructed and have emptied the colon distal to the intussusception so that appearance of feces is in them acceptable proof of reduction

3 *Disappearance of the mass* At times a mass is still palpable in a child in whom there is positive radiologic evidence of complete reduction of the intussusception The mass in such cases is the swollen edematous bowel previously forming the intussusceptum The enlarged mesenteric lymph nodes which regularly accompany an intussusception may form part of such a palpable post reduction mass On the other hand a very small intussusception still persisting in the region of the ileo cecal valve may no longer be palpable although still present and significant

4 *Clinical improvement of the child* who often falls into a natural sleep This is dramatic and fairly constant As Nordentoft points out incomplete reduction frequently relieves symptoms temporarily so that this sign too is merely confirmatory

5 *Subsequent recovery in the stool of the charcoal* given by mouth or the appearance of a *blood free stool*

Most of the children are so listless and apathetic that the barium enema seems to cause them little distress and it is scarcely necessary to restrain them If restraint is required elastic bandages holding the extended joined hands and the extended feet will decrease the necessity for exposing assistants In some of the older children it is necessary for properly protected assistants to restrain the hands and feet

In only a single instance have we had what might be considered an untoward reaction to this treatment This was in a five month old colored female infant who had been brought to the hospital because of vomiting and a frank upper respiratory infection However her vom

Fig 32 (pages 81 82 83) Reduction by Barium Enema Alone A B Male three years eight months old This child was seen five hours after the onset of severe abdominal pain There was a transverse epigastric mass His condition was good Barium flowed freely up the descending colon and around the splenic flexure to meet an obstruction in

A the transverse colon just proximal to the left of the midline

B The filling defect slowly and progressively moves across the transverse colon to the right of the midline

C More barium is beginning to pass between the intussusceptum and the intussuscipiens There is a large filling defect in the barium column and the beginning of oval rings of barium in the folds of the edematous intussusceptum

D & E As the barium reaches the hepatic flexure the fit is much looser and a good deal more barium seeps between the layers of the intussusception producing the striking filling defect and the coiled spring appearance

F The hepatic flexure is filling more completely but the filling defect persists.

G The right colon and hepatic flexure have filled completely and the filling defect is now visible down in the ascending colon

H The ascending colon is very largely filled and the outline of the cecum can be seen but it has not filled completely although there is no obvious filling defect

I The cecum now appears to have filled fairly densely and there is a little barium medial to it which must be in the small bowel

J With a rush many loops of small bowel have filled and the cecum appears to have filled completely as well

K A detail of the small bowel loops shows no abnormalities and

L After withdrawal of the balloon catheter and with expulsion of most of the barium nicely filled loops of small bowel are seen discrete from the large intestine

The child left the hospital well in three days.


A
B
C
D

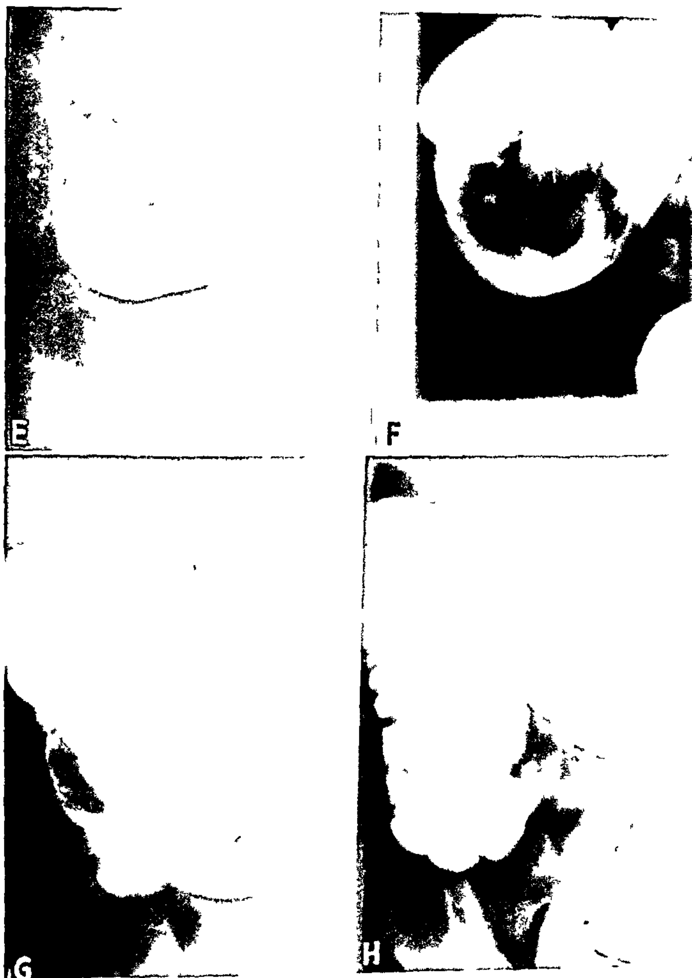


Fig 3 (Cont)



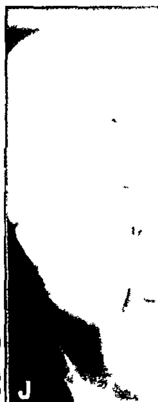




Fig 3 (Cont)

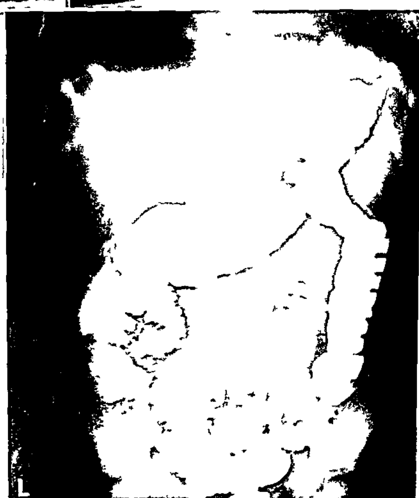




Fig 33 Reduction by Barium Enema Alone T W Female 8 months old This child developed diarrhoea and abdominal cramps 18 hours before coming to the hospital began to pass bloody mucus 21 hours before admission to the hospital had vomited two or three times on the first day of symptoms but had taken and retained some feedings She was apathetic quiet and prostrated The abdomen was relaxed There was a fullness in the lower abdomen and there was an easily palpable curved firm and movable mass extending from the umbilicus into

iting had come on coincidentally with an attack of abdominal pain during which she had drawn her legs up cried and vomited In spite of this vomiting pain and a lethargy which was noted in the records she was sent home diagnosed as an acute nutritional disturbance In the two and a half hours which had transpired since the onset of her illness she had not passed blood and actually no blood was passed until she had been home almost ten hours more She was finally brought to the hospital 32 hours after the onset of the illness when she was prostrated dehydrated and had an easily palpable mass in the left lower quadrant The barium enema encountered the intussusception in the descending colon (Fig 11) whence it was easily reduced to the splenic flexure in a period of five minutes and to the hepatic flexure in another ten minutes There was then no change for 30 minutes of steady pressure It is quite obvious that at this point the child should have been taken to the operating room However two subsequent and fairly deliberate attempts were made at reduction by barium enema and on the third trial some barium was seen to pass into the ascending colon and cecum Since it

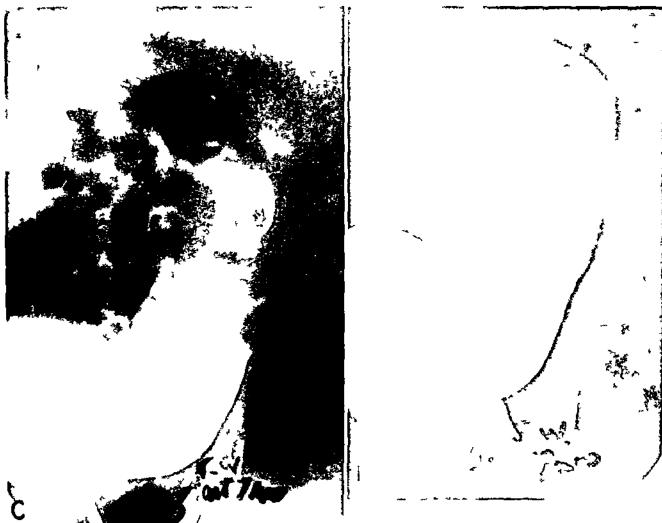


Fig 33 (Cont)

the left lower quadrant and easily palpable rectally as well Barium enema at once showed an intussusception in the rectum As seen in A the intussusceptum reached low into the rectum Barium has begun to pass between the intussusceptum and intussuscipiens The outline of the distended rectal balloon is sharply visible In B the concave meniscus of barium is seen to have reached the sigmoid and in C the ascending colon In both D and

did not fill the ileum the child was ordered to the operating room Before she could get there she developed generalized tonic and clonic convulsions and had two subsequent seizures of the same type The operation was postponed for several hours on this account but when it was finally undertaken the intussusception was found completely reduced The child very slowly recovered from the effects of these convulsions the cause and nature of which remained uncertain

Results

In the 77 intussusceptions treated by barium enema 53 have been reduced by the barium enema alone an incidence of 69% (Fig 28) Of the 24 patients who were operated upon there were five in which the reduction had been achieved by the barium enema so that the operation was merely confirmatory The barium enema therefore completely reduced the intussusception in 58 of the 77 cases or 75% There have been no deaths

Recurrence

We have had three recurrences in the 77 cases The first recurrence was in a 13 month old colored male first seen two weeks after the onset of abdominal pain and vomiting with constipation anorexia and cramps He had cran



Fig 33 (Cont.)
E a little barium has passed between the intussusceptum and intussuscipiens to outline the splenic flexure *In E* and F the splenic flexure fills progressively

berry colored stools was moderately prostrated markedly dehydrated and had a large mass in the epigastrium The barium enema encountered the distal end of the intussusception at the splenic flexure whence it was promptly reduced into the ileum which filled well Charcoal given by stomach tube was recovered five hours later in a spontaneous stool and the following morning he passed a normal stool felt well had no palpable mass He then remained asymptomatic until 18 hours after the enema reduction when he vomited twice and shortly after passed a currant jelly stool and had a doughy mass palpable in the left lower quadrant extending up to the left upper quadrant and across the midline By barium enema the intussusception was once more reduced with filling of the ileum although there remained a filling defect in the cecum *Operation* disclosed an intussusception of the appendix itself (see Fig 8) It seems possible that the intussusception of the appendix persisted after the first reduction but had not been observed fluoroscopically as it had in the second reduction The child remained well after resection of the appendix and part of the cecum

The second recurrence was in a child of seventeen months in whom an intussusception had previously been reduced by barium enema 15 months before when she was two months old The second intussusception was similarly uneventfully reduced by barium enema

The third recurrence was in a child who had an intussusception of six hours which was en

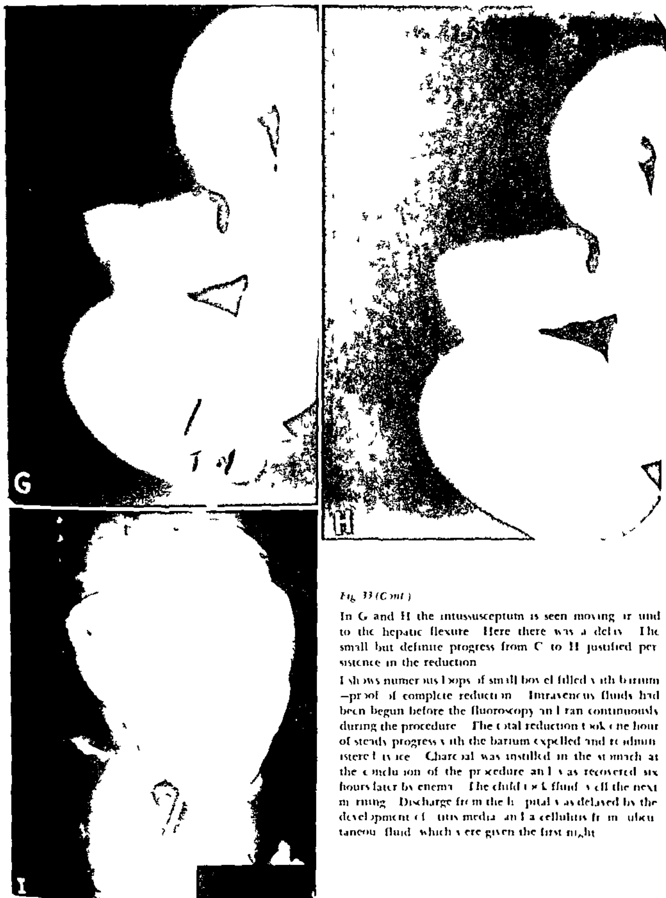


Fig. 33 (Cont.)

In G and H the intussusceptum is seen moving around to the hepatic flexure. Here there was a delay. The small but definite progress from G to H justified persistence in the reduction.

I shows numerous loops of small bowel filled with barium—proof of complete reduction. Intravenous fluids had been begun before the fluoroscopy and ran continuously during the procedure. The total reduction took one hour of steady progress with the barium expelled and readministered twice. Charcoal was instilled in the stomach at the conclusion of the procedure and was recovered six hours later by enema. The child took fluid well the next morning. Discharge from the hospital was delayed by the development of otitis media and a cellulitis from subcutaneous fluid which were given the first night.

countered at the mid transverse colon and readily reduced into the small bowel Charcoal administered through a stomach tube was recovered by enema some hours later and the child had normal stools and began taking fluids Sixty hours later she developed cramps and began vomiting again Another intussusception was found and this time the intussusception was reduced to the ileum but the ileum itself could not be filled The abdomen was explored and the intussusception found actually to have been completely reduced The appendix was removed The child has had no subsequent difficulty

Confirmatory Operation

There were four other patients in whom operation undertaken after an apparently incomplete reduction by barium enema served simply to prove that the intussusception had indeed been completely reduced The second such confirmatory operation was undertaken in a two and a half year old white girl admitted to the hospital with a ten day history of abdominal cramps and restlessness with frequent vomiting and only occasional retention of feedings She was prostrated quite markedly dehydrated acidotic and there was a palpable mass in the right upper quadrant A barium enema encountered an intussusception at the hepatic flexure This case was treated in 1942 when we assumed that a

(Text continued on page 100)



Fig 31 Reduction by Barium Enema Alone C. E. Female 4 months old This child was seen 151 hours after the onset of symptoms marked by vomiting followed by evidences of abdominal pain She had been given castor oil and 5 hours after the onset of symptoms passed blood with a stool She had been lethargic all day before the onset of frank symptoms The abdomen was soft there was some tenderness and resistance in the left lower quadrant where the mass could be felt quite readily The mass was easily palpable on rectal examination as well Intravenous fluids were administered through a saphenous cut-down

A Shows *the characteristic meniscus* of the advancing barium column already displaced past the splenic *flexure The intussusception reduced so quickly that* although the flow of barium was cut at once when the *intussusception* was outlined in the rectum the reduction proceeded to the splenic flexure before a film *could be taken*

B Shows the reduction progressed into *the mid* transverse colon with a filling defect in the barium column caused by the head of the intussusception



C Shows the filling defect even more plainly in the right side of the transverse colon



D Shows the barium filling the ascending colon



E. One can see incomplete filling of the cecum at the same time that the appendix is nicely outlined. Reduction to this point had been extremely rapid but at this point barium began to escape from the rectum. The catheter was withdrawn, the child allowed to expel the barium, the catheter reinserted, strapped in place, and the flow of barium resumed.



F Shows the filling of the many loops of small bowel which occurred with dramatic rapidity.

It is possible for the abdomen to be completely blanked out by overlapping of a distended sigmoid and a distended right colon without filling of loops of small bowel. For this reason the barium was evacuated through the catheter.



G Many loops of small bowel are quite distinctly visible
H The catheter was removed and after further evacuation there is no question of the adequacy of the reduction

Note the gastric tube visible in A F In all cases the stomach is emptied before the manipulation is begun Charcoal was deposited through this tube and appeared in a spontaneous stool five hours later The child fell asleep at the conclusion of the procedure but when awakened was a good deal more alert than previously A mild phlebitis at the site of her cut down kept her in the hospital for 6 days

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Fig 35 Reduction by Barium Enema Alone R I Female 8 months old This child had had diarrhoea for 24 hours which had ceased about 8 hours before admission to the hospital She had been vomiting for 3 hours before admission The child was not particularly ill the abdomen was soft a tubular mass was easily felt lying transversely above the umbilicus On barium enema the intussusception was encountered at the mid transverse colon Reduction proceeded rapidly to the mid ascending colon when the catheter was expelled On the second attempt the reduction proceeded to the cecum when again the catheter was expelled On the third attempt the small bowel filled freely These maneuvers required an hour and a half The child was lethargic on admission and during the procedure became normally reactive and cranky and the previously found mass was no longer palpable The child was in the hospital for 31 days

A Shows the intussusception encountered in the transverse colon immediately to the left of the vertebral column The meniscoid edge of the advancing barium column is plainly seen
B An oblique view a few moments later show the mid transverse colon with a sharp and clear meniscus
C Shows the barium seeping around the intussusception at the hepatic flexure

→

A

B

C

(Continued on next page)



Fig 37 Reduction by Barium Enema Alone H F Male 8 years old This boy came to the hospital (Mt S H) 46 hours after the onset of intermittent colicky abdominal pain He was known to have cystic fibrosis of the pancreas He had not vomited and had not passed blood His general condition was good and an easily palpable rounded soft mass was felt in the right lower quadrant We were called in consultation on this patient because a barium enema had demonstrated the intussusception and had reduced it from the transverse colon to the cecum but no further and the attempt had been abandoned and operation was contemplated Examination showed the patient still in good condition with an easily palpable mass in the right lower quadrant The catheter was reinserted and strapped in place and barium allowed to flow uninterruptedly from a height of 3 feet above the operating table without any manipulation of the barium or of the abdominal wall

A The intussusception had progressed once more and was now encountered just beyond the hepatic flexure producing the typical filling defect in the barium column Note the apparent double meniscus showing that the meniscoid pattern is caused in part by the protrusion of the intussusceptum into the intussuscipiens and in part by barium filling the edematous folds of the intussusceptum

B Reduction proceeded rapidly to the ascending colon which filled well

C The cecum filled poorly as it had originally and an irregular filling defect appeared









D As the barium was allowed to flow the cecum progressively filled with barium

Although there is still an obvious filling defect in the cecum there is at least one transverse lying loop of what must be ileum filled with barium It is important to continue the flow of barium at this point A false diagnosis of reduction may be made if a little barium slips into the ileum past an incompletely reduced intussusception

E Shows complete filling of the cecum and of many loops of small bowel *The abdomen had filled so completely* with barium before this film had been taken that it had not been possible to be certain that the opacity was caused by small bowel This film taken after evacuation of some of the barium shows free filling of many loops of small bowel

Six days later a repeat barium enema was performed because in children of this age causative lesions are more commonly found than in infants No such lesion was demonstrated



Fig 38 Reduction by Barium Enema Alone D B Female 8 months old This patient was admitted to the hospital 24 hours after the onset of vomiting Her mother stated that the child was constipated and seemed to be having abdominal pain The child had had an upper respiratory infection for several days She was extremely prostrated and dehydrated and passing bloody mucus per rectum There was resistance in the right upper quadrant where a mass was thought to be palpable On barium enema the intussusception was encountered on the left side of the transverse colon and was rapidly and completely reduced with free filling of the small bowel

A Shows the typical meniscus encountered in the transverse colon just to the left of the vertebral column

B The intussusceptum has been reduced a little blunting the horns of the meniscus





C The intussusception is found to be reduced to the hepatic flexure. Here as the bowel becomes of larger caliber and there is more space between the intussusceptum and the intussuscipiens we begin to see numerous coil like shadows of barium passing between the intussusceptum and the intussuscipiens.

D Numerous loops of small bowel are seen to have filled and the colon is completely outlined and filled. The child left the hospital well on the 6th day.



Fig 39 Reduction by Barium Enema Alone B A Female 7 months old This infant was seen 3 hours after she awakened screaming with pain and doubling up her thighs A few moments later she had a normal bowel evacuation and began to vomit The paroxysms of pain and vomiting recurred at 10 to 15 minute intervals She was lethargic but not shocked There was a firm sausage shaped mass lying transversely across the abdomen just above the umbilicus The intussusception was reduced by barium enema in a matter of seconds In order to obtain the roentgenograms the flow of barium was momentarily interrupted for each exposure Charcoal deposited in the stomach appeared in a spontaneous stool 5 hours later Feedings were started the next morning and the child discharged in 6 days The intussusception was encountered at the splenic flexure where there is visible in

A The large filling defect caused by the intussusceptum and the long horns of the meniscus as the barium slips between the inner and outer coils preparatory to reducing the intussusception

B Shows filling of the colon and many loops of small bowel The pattern of the barium in the mid transverse colon is suggestive of a second colo-colic intussusception apparently retrograde but may be due to persistent edema The child had no further difficulty

chronic intussusception of this duration would not yield to a barium enema and the barium enema which was undertaken was meant to be purely diagnostic. It was undertaken by the radiologists who said that there was no tendency for the intussusception to reduce. Operation was proceeded with although the mass seemed less *definite than it had before*. At *operation* there was no intussusception but the entire ascending colon and an inch or two of the terminal ileum were edematous, thickened and covered with fibrin. The child had no subsequent difficulty.

The third purely confirmatory operation was performed in a ten month old white male who was seen *12 hours* after the onset of bloody rectal discharge and abdominal pain. He had a mass in the right mid abdomen and barium enema showed the intussusception in the mid transverse colon. The cecum did not appear to fill *although the intussusception* was at least partially reduced and operation was undertaken. With the abdomen open there was seen only edematous and injected terminal ileum and cecum with no remaining intussusception.

The fourth confirmatory reduction was in a child of six months who had come to the hospital twelve hours after he had suddenly begun to *scream with pain*. *He was passing bloody* rectal discharge and had a sausage shaped mass lying transversely in the epigastrium. On barium enema (Fig 10) the intussusception was first localized distal to the splenic flexure in the upper part of the descending *colon*. *It was* slowly reduced through the splenic flexure, transverse colon, hepatic flexure and ascending colon to the cecum. The terminal ileum was then visualized lying to the right of the cecum and filled *for four inches only*. For this reason operation was undertaken but the intussusception was found to be completely reduced, the bowel being simply somewhat edematous.

The last merely confirmatory operation was that performed on the five month old child previously mentioned because of the convulsions occurring after the barium enema reduction (Fig 41). Again in this instance the terminal ileum was seen to fill only for four inches and operation was undertaken on the suspicion that the intussusception had not been completely reduced. At operation the intussusception was found to have been completely reduced and the appendix was removed.

Completion of Reduction by Operation

The wisdom of the exploratory operations performed in the last two cases because of incomplete filling of the ileum is demonstrated by another patient, one of the two in whom an incorrect diagnosis of complete reduction was made. This was a four year old girl with a *24 hour intussusception which was encountered* at the hepatic flexure and reduced into the terminal ileum. It was noted that only six or seven inches of the terminal ileum filled but *the* child was allowed to return to the ward. She began to vomit again several hours later. A mass was once more palpable and it was again demonstrated on barium enema to be an intus*susception*. It was reduced to the cecum but no further. Operation was undertaken and after the remainder of the intussusception had been reduced manually there was disclosed a Meckel's diverticulum 15 inches proximal to the ileocecal valve. The Meckel's diverticulum was resected and the child did well.

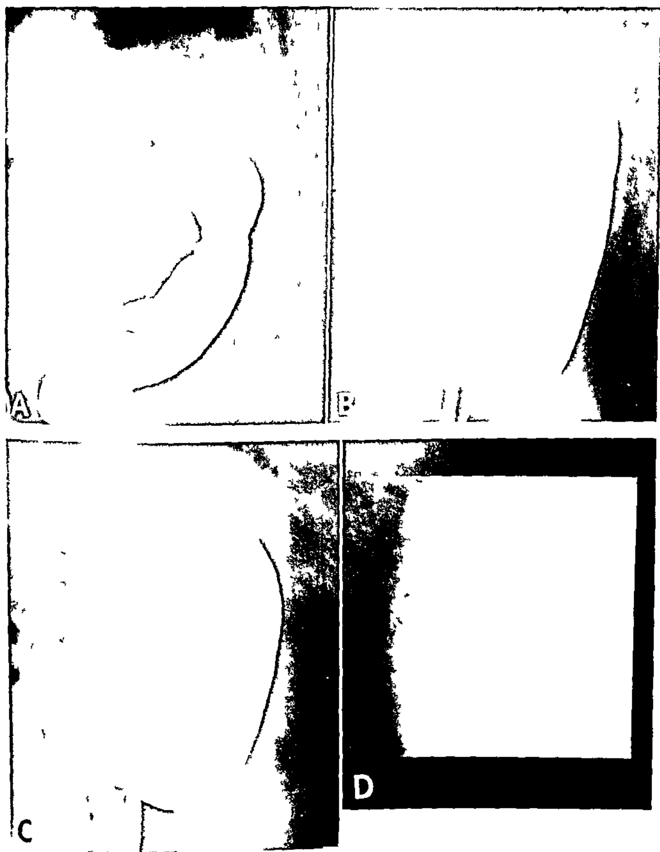
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Fig 10 Operative Confirmation of *Complete Reduction* by Barium Enema. W. C. 6 months old. This child came to the hospital 12 hours after he had suddenly *began to scream with pain*. *He* was passing a bloody rectal discharge and had a sausage shaped mass lying transversely in the epigastrium. He was "knocked-out" and dehydrated and at the same time restless. The abdomen was scaphoid and completely relaxed. The sausage shaped mass was easily felt lying transversely above the umbilicus. There was dark blood in the rectum. Barium enema was undertaken at once.

A. The intussusception was met just distal to the splenic flexure in the upper part of the descending colon. It was *slowly and progressively displaced proximally*.

B & C. Show the splenic flexure filled and the meniscus advancing into the transverse colon.

D. The meniscus has flattened out as the intussusception has been still further reduced across the transverse colon.


A
B
C
D









E, F & G Show the progressive filling of the transverse colon and hepatic flexure

H Shows a sudden filling of the ascending colon with barium beginning to outline the filling defect in the cecum

I Shows the cecum very largely filled and with no sharp filling defect in the wall of the cecum but the terminal ileum has not filled

J Shows a loop of terminal ileum quite clearly filled and lying lateral to the colon, a not uncommon location for the terminal ileum. There is actually visible a concave edge to the upper end of the barium column and this was correctly interpreted as a meniscus indicating incomplete reduction

(Continued on next page)



Although the procedure had required one and a *half hours* progress had been steady and the child's condition was excellent. Because one cannot depend upon reducing intussusceptions *which have demonstrably* begun well proximal to the ileocecal valve it *has been our practice* to abandon hydrostatic pressure and resort at once to operation whenever there is an obvious delay in the terminal ileum as was evidenced *in this case*. In accordance with that practice this child was taken to the operating room. At operation through a McBurney incision the cecum was found to be edematous and the small bowel to be essentially normal with no intussusception present. The appendix was removed and the child *left the* hospital well on the tenth day. The child had *a bland course* and there is no indication in the record *of the reason for* the long hospitalization. Whenever *there is doubt as* to the completeness of reduction *or whenever* as in this case barium is clearly seen to *enter the* small bowel and then to delay operation should be undertaken. Under no circumstances should the child be given a trial by labor and allowed to demonstrate clinically whether reduction has been complete or not. We much prefer to operate and find *the* intussusception reduced rather than to delay and *run the risk that* an intussusception has been incompletely *reduced*. A small McBurney incision *allows for adequate exploration* of the terminal *ileum reduction of the persisting portion of the intussusception if one is found* and removal of the appendix.



Fig. 41 Operative Confirmation of Complete Reduction by Barium Enema C. A. Female 5 months of age This child's treatment represented unwise and stubborn persistence in use of the barium enema which we feel to have been quite improper despite the ultimately successful outcome The child was seen in the Out-patient Department two hours after the onset of abdominal pain which caused her to draw her legs up with each spasm She had vomited several times and had an obvious upper respiratory infection She was sent home diagnosed as an acute nutritional disturbance and instructed to return the next day The child was not brought back until two days later 52 hours after the onset of her symptoms In the meantime she had been vomiting repeatedly and had become lethargic and had passed bloody material from her rectum She was prostrated and dehydrated and a mass measuring 4 x 4 centimeters was easily felt in the left lower quadrant In the rectum there was a currant jelly stool A barium enema was begun shortly after the child was admitted to the hospital and it was recorded in the chart that the intussusception encountered in the descending colon was easily reduced to the splenic flexure in five minutes and to the hepatic flexure in ten minutes where there was no change for the next thirty minutes A second trial was made after the child was given a brief rest and in twenty five minutes again no progress was made A third trial was made at once and this time after fifteen minutes some barium was seen in the ascending colon and cecum No further progress being made after another thirty minutes the effort was abandoned and the child was dispatched to the operating room

A Numerous dilated loops in the plain film obviously indicate an intestinal obstruction of some character None of the dilated loops are identifiable as colon

(Continued on next page)

It may be of interest to see the status of the *intussusception at operation* in the other cases incompletely reduced by the barium enema

2 In a six month old male infant an intussusception of 30 hours was encountered at the hepatic flexure and reduced by barium enema to the cecum The appendix filled but only a little barium entered the ileum (Fig. 42) Through a McBurney incision a small stub of *ileum* was reduced from the cecum and the appendix removed

3 In a *seven month* old male an intussus-

B

C

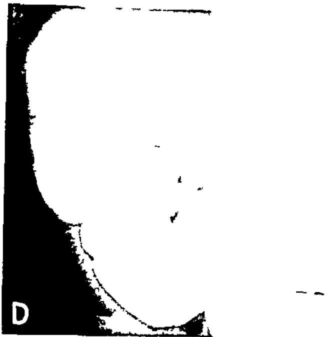
B The intussusception is met in the distal transverse colon fluoroscopically it was first seen in the descending colon

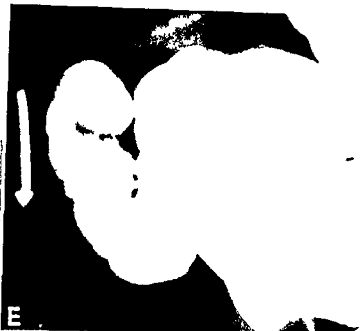
C In this oblique view of the transverse colon one sees the barium infiltrating between the layers of the intussusception the intussusceptum producing a spherical filling defect (Continued on next page)

ception of 27 hours was encountered distal to the splenic flexure The cecum filled but the ileum did not Eight hours later cramps recurred and on a repeat enema the cecum began to fill but the ileum did not This was the seventh case in our barium enema series our only other mistaken diagnosis of complete reduction and was one of those which convinced us that operation must be undertaken at once if the ileum fails to fill freely At operation an ileoileal intussusception which had passed into the cecum was found and reduced the leading point of the intussusception 12 centimeters from the ileocecal valve was cyanotic and a segment two or three centimeters in length was resected and an anastomosis performed Microscopic studies showed this to be perfectly viable bowel (Plate IID) The child did well

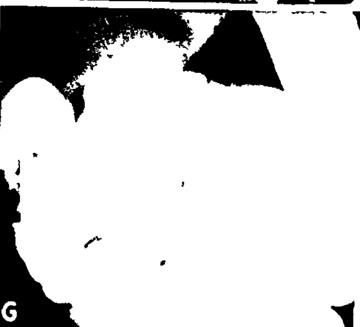
4 In a child of eight months an intussusception of eight hours was encountered on barium enema at the splenic flexure and was reduced to the ileo cecal valve without filling of the ileum At operation about one inch of ileum was gently pressed out of the cecum through a McBurney incision

5 In a six month old infant with an intus









D Shows the intussusception nearing the hepatic flexure *and*

E Shows the hepatic flexure filled

F Shows the barium passing down into the ascending colon and the cecum and

G One sees the cecum still further filled This is the last film which was taken There is a suggestion in the middle of the field of loops of small bowel which have been filled even though there is still a filling defect in the cecum

Before she could get to the operating room the child had the first of three severe generalized tonic and clonic convulsions which delayed operation for a period of several hours. When operation was finally undertaken the intussusception was found to have been completely reduced either by the barium enema or subsequent to that Eighteen inches of distal ileum the cecum and the proximal ascending colon were engorged with blood edematous and swollen and had obviously been included in the intussusception There were numerous enlarged succulent lymph nodes in the neighborhood of the ileocecal valve The child did not awaken for nine hours after anesthesia but thereafter made a good recovery and was taking fluids by mouth on the third day She was discharged well on the fifteenth day The initial error in the dispensary was the result of an inadequately high index of suspicion The only deaths from intussusception in the Johns Hopkins Hospital in the last 19 years (the last one 12 years ago) were in children in whom the diagnosis had been similarly missed *at the hospital* In the present instance the child's life was probably saved in spite of the over vigorous and persistent attempts at reduction because intravenous fluid administration had been begun even before reduction had been attempted and because reduction having finally been achieved resection was not

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Fig 49 Operative Completion of Incomplete Reduction by Barium Enema W A Male 6½ months old This child came to the hospital 30 hours after the onset of irritability abdominal pain and vomiting He first passed bloody clots following a rectal examination in the hospital but had been vomiting up to the time of admission although he had been able to take a little water There was slight resistance in the right upper quadrant but no mass could definitely be felt Upon barium enema fluoroscopy the intussusception was encountered with its apex at the hepatic flexure it was readily reduced to the cecum and could not apparently be reduced further The barium was observed to pass freely into the appendix and some barium passed into the ileum but the ileum did not fill freely and a mass was now palpable in the region of the cecum for the first time At operation through a right McBurney incision a small nubbin of ileum was found still to be protruding into the cecum and was easily reduced An appendectomy was performed and the child left the hospital well on the 8th day

A Shows the filling defect of the barium column just to the left of the hepatic flexure with the characteristic meniscus and oval filling defect

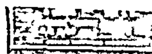
B The intussusception has been further reduced toward the hepatic flexure one can see a few rings of barium around the negative shadow of the intussusceptum as the barium seeps between the intussusceptum and the intussuscipiens (Continued on next page)

susception of 28 hours duration an intussusception filling the ascending colon was rapidly and almost instantaneously reduced to the cecum but without filling of the small bowel At operation a nubbin of ileum was reduced through the ileo cecal valve and the appendix removed

6 In a male of three months an intussusception of over 96 hours duration was encountered in mid sigmoid and reduced to the ascending colon with the barium enema At operation with some difficulty the reduction was completed This child did well but returned three months later and was operated upon for acute mechanical intestinal obstruction due to adhesions and had one further bout of obstruction a month later which was treated without operation The note was made at the original operation that the muscularis and serosa of the ascending colon were badly damaged although the bowel was considered viable as it in fact proved to be

←←

required One is justified in maintaining hydrostatic pressure upon the bowel so long as there is persistent and steady reduction of the intussusception slow though it may be If no progress is made the patient should be sent to the operating room which has been held in readiness. Stubborn determination to achieve a cure by barium enema has no place in a rational therapeutic policy This is the only instance in which we have seen convulsions in association with intussusception reduced by barium enema







C Shows the intussusception reduced to the ascending colon with a good deal of barium passing now between the intussusceptum and the loosely fitting intussuscipiens

D The final film there is seen some barium in the appendix and some in the terminal ileum but an obvious persistent filling defect in the cecum The apparent filling defect high in the ascending colon is of course a peristaltic wave

As in this case operation must be undertaken promptly unless there is free filling of the ileum with barium and without any persistent deformity of the cecum (From Ravitch and McCune *Ann Surg 1 S 1948*)

None of the children who have had reduction of intussusception by barium enema alone have had subsequent attacks of mechanical intestinal obstruction and this is the only one of the children with reduction completed by operation who had such intestinal obstruction

7 This thirteen month old male is mentioned under recurrence of intussusception after barium enema reduction An intussusception of 11 days duration with a typical history was encountered at the splenic flexure It was reduced to the cecum and the small bowel could be seen filling well Charcoal given by stomach tube was passed by rectum five hours later The child had normal stools appeared perfectly well without a palpable mass and was asymptomatic *until 18 hours after the reduction when* the symptoms of intussusception recurred There was a mass in the left lower quadrant The intussusception was reduced from the descending colon or sigmoid to the cecum where a small filling defect remained At operation the only intussusception remaining was found to be that of the appendix which was removed together with its base of cecal wall The child did well

8 In a 13 month old male an intussusception of 27 hours duration was encountered on barium

enema in the left transverse colon and red[illegible] through the cecum up into the ileum Sc[illegible] inches of ileum filled and then a typical [illegible] effect could be seen in the ileum At oper[illegible] through a McBurney incision a small [illegible] intussusception was reduced without diff[illegible] and the appendix was removed

9 An intussusception of 53 days dur[illegible] an eight month old child was reduced fr[illegible] splenic flexure to the cecum At oper[illegible] button of ileum in the cecum was flicked

10 An intussusception of 12 hours du[illegible] in an 11 month old female was encount[illegible] the left side of the transverse colon and re[illegible] to the cecum (Fig 43) At operation [illegible] nubbin of ileum was easily popped b[illegible] the bowel and the appendix removed

11 In a 29 month old female in pro[illegible] apathy with an 18 hour intussusception barium enema rapidly reduced the intussusception from the midtransverse colon to the cecum [illegible] small bowel did not fill readily At o[illegible] 14 inches more of intussusception was r[illegible] disclosing a Meckel s diverticulum which [illegible] resected

12 An intussusception of 28 hours in an eight month old child was reduced from the sigmoid to the ascending colon At operation the remainder of the intussusception was readily reduced

13 This was a four year old child with a 57 hour old intussusception presenting in the left transverse colon The cecum did not fill completely and at operation the tiny remaining portion of the intussusception at the ileo cecal valve reduced just as it was being demonstrated with a sponge stick in the abdomen

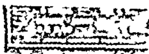
14 In a child of 15 months a 46 hour old intussusception presenting at the recto sigmoid was reduced to the cecum in 30 minutes of steady progress The ileum did not fill At operation the last bit of the intussusception was flicked out of the cecum and the appendix was removed

15 In a seven year old boy with a five hour intussusception reaching the hepatic flexure the barium enema reduced the intussusception to the cecum but no further At operation twelve

[illegible] in did [illegible] in the [illegible] the thumb [illegible]

[illegible] e intussuscep[illegible] d This was [illegible] with a [illegible] hour intus[illegible] reached the splenic flexure [illegible] the hepatic flexure in 30 min[illegible] (Fig 27) but could not be further reduced Operation was undertaken at once the bowel defied reduction and a resection and primary end to end anastomosis was performed The child left the hospital well in ten days No primary lesion was found in the bowel

In an additional case listed as requiring operation in addition to the barium enema an intussusception of only five hours duration in a boy two years and four months old was encountered in the mid transverse colon and completely and readily reduced by the barium enema The barium entered the small bowel freely the mass was no longer palpable and within six hours the child passed charcoal and stool He seemed quite well Six and a half hours after reduction he developed cramplike abdominal pain and began to pass blood and mucus together with stool No mass reappeared until after 24 hours when a vague mass was felt and it was thought that he had a recurrence At operation the terminal ileum for three or four inches and the cecum and proximal ascending colon were tremendously thickened and indurated and it was







C Shows the intussusception reduced to the ascending colon with a good deal of barium passing now between the intussusceptum and the loosely fitting intussuscipiens

D The final film there is seen some barium in the appendix and some in the terminal ileum but an obvious persistent filling defect in the cecum The apparent filling defect high in the ascending colon is of course a peristaltic wave

As in this case operation must be undertaken promptly unless there is free filling of the ileum with barium and without any persistent deformity of the cecum (From Ravitch and McCune *Ann Surg 128* 1948)

None of the children who have had reduction of intussusception by barium enema alone have had subsequent attacks of mechanical intestinal obstruction and this is the only one of the children with reduction completed by operation who had such intestinal obstruction

7 This thirteen month old male is mentioned under recurrence of intussusception after barium enema reduction An intussusception of 11 days duration with a typical history was encountered at the splenic flexure It was reduced to the cecum and the small bowel could be seen filling well Charcoal given by stomach tube was passed by rectum five hours later The child had normal stools appeared perfectly well without a palpable mass and was asymptomatic until 18 hours after the reduction when the symptoms of intussusception recurred There was a mass in the left lower quadrant The intussusception was reduced from the descending colon or sigmoid to the cecum where a small filling defect remained At operation the only intussusception remaining was found to be that of the appendix which was removed together with its base of cecal wall The child did well

8 In a 13 month old male an intussusception of 27 hours duration was encountered on barium

enema in the left transverse colon and reduced through the cecum up into the ileum. Several inches of ileum filled and then a typical filling effect could be seen in the ileum. At operation through a McBurney incision a small ileoileal intussusception was reduced without difficulty and the appendix was removed.

9. An intussusception of 53 days' duration in an eight month old child was reduced from the splenic flexure to the cecum. At operation a button of ileum in the cecum was flicked out.

10. An intussusception of 12 hours' duration in an 11 month old female was encountered in the left side of the transverse colon and reduced to the cecum (Fig. 43). At operation a small nubbin of ileum was easily popped back into the bowel and the appendix removed.

11. In a 29 month old female in profound apathy with an 18 hour intussusception barium enema rapidly reduced the intussusception from the midtransverse colon to the cecum. The small bowel did not fill readily. At operation 14 inches more of intussusception was reduced disclosing a Meckel's diverticulum which was resected.

12. An intussusception of 28 hours in an eight month old child was reduced from the sigmoid to the ascending colon. At operation the remainder of the intussusception was readily reduced.

13. This was a four year old child with a 57 hour old intussusception presenting in the left transverse colon. The cecum did not fill completely and at operation the tiny remaining portion of the intussusception at the ileo cecal valve reduced just as it was being demonstrated with a sponge stick in the abdomen.

14. In a child of 15 months a 46 hour old intussusception presenting at the recto sigmoid was reduced to the cecum in 30 minutes of steady progress. The ileum did not fill. At operation the last bit of the intussusception was flicked out of the cecum and the appendix was removed.

15. In a seven year old boy with a five hour intussusception reaching the hepatic flexure the barium enema reduced the intussusception to the cecum but no further. At operation twelve inches of ileum was reduced and the appendix removed.

16. In a three and a half year old boy with a 14 hour intussusception at the hepatic flexure the intussusception was reduced into the ileum which failed to fill freely. At operation the intussusception was found to extend far proximally into the ileum and to have arisen in a large lymphoid patch about three feet proximal to the ileocecal valve. Reduction was easily accomplished and the appendix removed.

17. In a three year old boy an intussusception of six hours' duration had reached the left side of the transverse colon. The barium enema reduced it quickly to the cecum. The ileum did not fill. At operation a button of ileum in the cecum was readily pushed back with the thumb and forefinger.

18. In only a single case was the intussusception irreducible and bowel resected. This was in a five month old female with a 24 hour intussusception which had reached the splenic flexure. It was reduced to the hepatic flexure in 30 minutes by barium enema (Fig. 27) but could not be further reduced. Operation was undertaken at once the bowel defied reduction and a resection and primary end to end anastomosis was performed. The child left the hospital well in ten days. No primary lesion was found in the bowel.

In an additional case listed as requiring operation in addition to the barium enema an intussusception of only five hours' duration in a boy two years and four months old was encountered in the mid transverse colon and completely and readily reduced by the barium enema. The barium entered the small bowel freely the mass was no longer palpable and within six hours the child passed charcoal and stool. He seemed quite well. Six and a half hours after reduction he developed cramplike abdominal pain and began to pass blood and mucus together with stool. No mass reappeared until after 21 hours when a vague mass was felt and it was thought that he had a recurrence. At operation the terminal ileum for three or four inches and the cecum and proximal ascending colon were tremendously thickened and indurated and it was

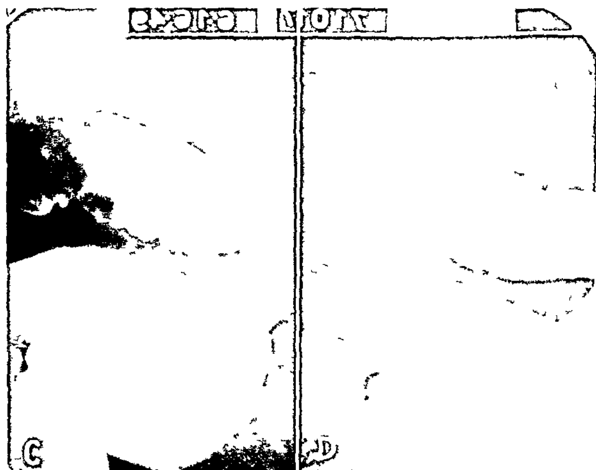


Fig 13 Operative Completion of Incomplete Reduction by Barium Enema I G Female 11 months old This child was seen 12 hours after the onset of spasms of periodic abdominal pain She vomited immediately after the onset and repeatedly thereafter She took feedings when offered but was unable to retain them She was a well nourished child in good condition The abdomen was very soft and relaxed There was an easily visible and palpable sausage shaped mass in the right upper quadrant four by three centimeters in diameter There was a little tenderness over the mass

(Continued on next page)

thought that it might be the site of a tumor perhaps a lymphosarcoma For this reason the terminal ileum and the right colon were resected and an anastomosis performed Plate IIC of the specimen shows merely the changes consistent with viable bowel at this period after reduction of an intussusception The child did well although he returned subsequently with a mechanical obstruction due to adhesions which required operation

In two other cases listed as requiring operation and very early in the series the operators agreed to the performance of hydrostatic pressure reduction on the operating table with the open abdomen The first of these was a six month old female with an intussusception of 15 hours duration At operation the intussusception was readily palpated in the sigmoid colon A Foley bag catheter had been placed in the rectum the balloon distended and the catheter connected to a bottle of intravenous saline solution This was allowed to run into the bowel while the operator and first assistant each maintained a finger on opposite sides of the intussusception in the abdomen At the end of five minutes when neither observer had noticed any change in the position or tenseness of the intussusception the attempt was discontinued the hands removed and the bowel examined To our surprise the intussusception had reduced completely and this had all been accomplished so swiftly smoothly and gently that our fingers holding the intussus



A. The intussusception was encountered at the distal transverse colon but the first film taken shows that it has already been reduced to the mid transverse colon

B C and D Show progression of the reduction across the transverse colon

(Continued on next page)

ception had not perceived the change in tension as the intussusception was reduced and the bowel filled with saline solution The same procedure was employed in an eight months old male with an intussusception of 36 hours duration This intussusception had reached the descending colon and was similarly reduced very rapidly to the cecum The final portion of the intussusception could not be reduced until sterile mineral oil had been introduced between the layers of the intussusception and very firm manual pressure made on the cecum just distal to the intussusception This child also did well

We feel strongly that barium enema can and should be administered to every child with intussusception regardless of the duration of the disease or the child's condition Recent and previous experience and experimental studies together with the great mass of reported cases convince us that if manual pressure is avoided and if the barium cannister is no higher than three and a half feet above the operating table gangrenous bowel will not be reduced and perforation of the intestine will not occur We have seen children in such a degree of collapse that it seemed almost certain that the bowel must be gangrenous who have yet had intussusceptions reduced while blood was being administered and have not required operation It is scarcely possible to make an absolute diagnosis of gangrene of an intussusception with accuracy without operation No time is lost by the use of the barium enema since the operating room is being gotten in readiness and the child is having a gastric aspiration and supportive intravenous fluid therapy or transfusion at *the same time* Furthermore even if the intussusception should prove to be incompletely reduced by barium





E The splenic flexure has been passed and barium is passing around the intussusceptum in the ascending colon

F The transverse colon and ascending colon and cecum are filled However there is still a partial filling defect in the cecum and no barium has proceeded into the small bowel It is obvious that the balloon catheter has been expelled and that there is leakage of barium on the sheets The operator did not reinsert the catheter into the rectum and attempt another enema but proceeded at once to operation At operation a small nubbin of ileum was found in the cecum and through the small McBurney incision was readily reduced with pressure of the thumb The appendix was removed and the child was discharged from the hospital on the 8th day

This was an early case If the catheter is kept in place without leakage such intussusceptions will usually reduce completely without operation If the catheter is expelled reinsertion in such case with another flow of barium will usually bring success.

enema the more of the intussusception that is reduced by the enema the less remains to be done in the operating room The problem of reducing an intussusception found at operation to be in the right colon or in the cecum is quite another one from that of reducing an intussusception from the rectum or sigmoid entirely around the colon

Except for the first few cases most of the incisions in cases requiring operative completion of the reduction have been right lower quadrant McBurney or lateral transverse incisions which expose little more of the peritoneal cavity than the cecum and terminal ileum The one case of intestinal obstruction due to adhesions occurring subsequent to operative completion of reduction was in one of the earlier cases where a vertical right rectus retracting lower abdominal incision was employed

Most reports of extensive clinical experience with intussusception mention the occurrence of mechanical intestinal obstruction due to adhesions some time after operative reduction of intussusception In view of the formal laparotomy required and the extensive handling of the already traumatized bowel his is small wonder and marks a sharp difference from the experience of clinics employing primary hydrostatic pressure reduction

Packard reports two such instances of subse

quent mechanical intestinal obstruction in 43 children previously treated for intussusception by primary operation Thurston Holowich and McCoy in 109 operations for intussusception report 7 cases of mechanical obstruction due to adhesive bands occurring from two months to three and one half years post operatively Kahle reports 4 such obstructions 2 of them fatal in 88 cases We reported in 1950 12 cases of mechanical intestinal obstruction (3 of them fatal) developing weeks months or years after operative reduction in the early series at the Johns Hopkins Hospital

This is therefore a serious complication and the deaths should fairly be attributable to the treatment of intussusception by the operative method

Although we are convinced that all children with intussusception deserve a trial at barium enema and expect that between 70 and 75% of them will be cured by the barium enema we are emphatic that the barium enema should not be stubbornly persisted in If at any point absolutely no progress is made for ten or fifteen minutes the attempt should be abandoned and operation proceeded with On the other hand so long as there is any progress however slow the attempt should be persisted in

It is our feeling that the barium enema reduction of an intussusception is as much a surgical procedure as the manipulative reduction of a fracture or the cystoscopic removal of a ureteral stone The barium enema should be under the control of the surgeon who will make the decision when and if operation is to be performed and who will perform the operation As close cooperation with pediatricians and radiologists as can be achieved is desirable but the surgeon should be present at all such manipulations and responsible for their conduct Any other course is certain to result in delays The only interpretation which can be placed on some series of hydrostatic pressure reductions which have presented a significant mortality is that a policy of hydrostatic pressure reduction at all costs was in force The barium enema should be considered as a diagnostic and therapeutic medium which results in accuracy of diagnosis in essentially all cases and which is curative in 70% to 75% of cases and enormously simplifies the task of the surgeon in the remaining 25% to 30%

Our own interest in intussusception was aroused in 1933 by the paper of Dr E H Miller of Chicago who described his dissatisfaction with his own poor results (45% mortality in 20 cases) and referred to the remarkable results of Hipsley in Australia with reduction of intussusception by hydrostatic pressure In reviewing the literature we were struck by the interesting fact that surgeons reporting in 1930 and 1940 mortalities of 20% and 30% for the treatment of intussusception scorned the non-operative methods which had a lower mortality in 1890 and in 1900 and which in 1926 gave a mortality as low as 5% in 100 consecutive cases treated by Hipsley

A paper of Hipsley s published in 1935 is o particular interest He reported on this occasion 486 cases of intussusception treated by te surgeons with an over all mortality of 11% Three of the ten surgeons always attempted preliminary reduction by saline enema and h a mortality of 9 8% The other seven sur operated on all patients without an attempt hydrostatic pressure reduction and had a 11% mortality This is a significant difference in large series of patients treated in the period of time and at the same hospital

Today there is essentially no mortality fr intussusception treated in the best pediatric su gical clinics except in the case of children ready irretrievably moribund at the time admission A comparative study of current tality statistics is therefore of little value Su a study published by us ten years ago w mortality from intussusception was not so showed a striking difference in the results clinics employing operative reduction prim and clinics employing hydrostatic pressure tion primarily with the balance heavily in fav of the latter

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It is our feeling that the barium enema reduction of an intussusception is as much a surgical procedure as the manipulative reduction of a fracture or the cystoscopic removal of a ureteral stone. The barium enema should be under the control of the surgeon who will make the decision when and if operation is to be performed and who will perform the operation. As close cooperation with pediatricians and radiologists as can be achieved is desirable but the surgeon should be present at all such manipulations and responsible for their conduct. Any other course is certain to result in delays. The only interpretation which can be placed on some series of hydrostatic pressure reductions which have presented a significant mortality is that a policy of hydrostatic pressure reduction at all costs was in force. The barium enema should be considered as a diagnostic and therapeutic medium which results in accuracy of diagnosis in essentially all cases and which is curative in 70% to 75% of cases and enormously simplifies the task of the surgeon in the remaining 25% to 30%.

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A paper of Hipsley's published in 1935 is of particular interest. He reported on this occasion 486 cases of intussusception treated by ten surgeons with an over all mortality of 11%. Three of the ten surgeons always attempted a preliminary reduction by saline enema and had a mortality of 9.8%. The other seven surgeons operated on all patients without an attempt at hydrostatic pressure reduction and had a 14% mortality. This is a significant difference in a large series of patients treated in the same period of time and at the same hospital.

Today there is essentially no mortality from intussusception treated in the best pediatric surgical clinics except in the case of children already irretrievably moribund at the time of admission. A comparative study of current mortality statistics is therefore of little value. Such a study published by us ten years ago when mortality from intussusception was not so rare showed a striking difference in the results of clinics employing operative reduction primarily and clinics employing hydrostatic pressure reduction primarily with the balance heavily in favor of the latter.

Nordentoft and Hansen have compiled the results of a colossal Danish experience with intussusception based on 1,012 cases treated be

tween 1928 and 1935 and 796 cases between 1944 and 1949 In the first period Nordentoft collected 419 cases of intussusception 204 were treated by barium enema alone and of these there were 12 deaths Two hundred and fifteen had a secondary operation 16 of which were merely confirmatory and 45 of these children died There were thus 57 deaths out of 419 cases a mortality of 13 6% in 1928 1935 a result outstanding for the time In 450 primary operations there were 116 deaths or a 25 8% mortality The remainder of the patients were treated by a water enema or by trans abdominal manipulation In Hansen s supplementary report there were 413 cases treated only by barium enema with two deaths and 302 cases secondarily operated upon (in 53 cases the operation was merely confirmatory) with 50 deaths There were thus 52 deaths in 715 cases a mortality of 7 3% The mortality during the same period out of 71 cases operated upon primarily was 18 9%—14 deaths The remainder of the patients were apparently undiagnosed and died without treatment Once more the mortality 7 3% was better than most American clinics were reporting in 1949 The cause of the deaths is only very briefly discussed In the earlier paper Nordentoft states among other things that while the pressure used is generally that of 1 to 1 2 meters it is never to go above 2 meters that is to say six feet! which is a great deal more than we think is safe Nordentoft states— if there is doubt about the reduction—which there will always be if the enema does not pass into the small bowel—an immediate final treatment will be indicated In early cases a brief delay to await developments will be warranted but should on no account exceed a very few hours This we consider to be dangerous advice If there is any doubt about reduction immediate operation should be undertaken A reading of Nordentoft s text would suggest that if reduction is not achieved repeated attempts are made during the first and usually only roentgen examination It would appear from Nordentoft s statements that the patients are the patients of the radiologic service for this treatment and this may quite naturally lead to over vigorous persistence in enema manipulation From Nordentoft s 1955 paper one gathers that in 1134 barium enema reductions four cases of rupture of the bowel occurred At all events Nordentoft s and Hansen s results are good for their time compare favorably with reports from other clinics but are not quite as good as one would have a right to expect

Helmer reports 130 cases of intussusception reduced with barium enema (over 80%) with no deaths In 30 additional cases in which laparotomy had to be resorted to in addition there were nine deaths a mortality of 5 6% for the whole material In the last three and a half years of the study that is to say from 1944 to 1947 there were nine cases operated upon one with a resection with no deaths This is considered to be due to improved anesthesia and post operative care

Recently Packard and Allen from the Denver Childrens Hospital and Kahle from the Charity Hospital in New Orleans have apparently begun to use the barium enema with increasing frequency On the other hand Dennison of Glasgow after a trial has given it up as unsatisfactory

Moore apparently attempted barium enema reduction in 17 cases and had only two successes in addition to one which was confirmed at operation He had one death following resection in his total of 13 cases and 5 deaths without resection The results seem unsatisfactory with all forms of treatment in this series

Francis and Friedman report from 1933 1955 38 cases treated by primary operation with four resections and two deaths In 7 cases barium enema was employed—four with complete reduction and three requiring operative completion As a result they advise barium enema by the surgeons as the first step in treatment

Santulli and Ferrer from the Babies Hospital in New York recently used primary barium enema reduction in 30 cases with complete reduction in 12 without operation and complete reduction in six more confirmed at operation that is to say 60% in all Zachary in Sheffield

after initial resistance has finally tried the barium enema and has been successful in 33 cases out of 54 He points out that his incidence of success has been highest in the intussusceptions under 24 hours and in babies older than six months Combining these two features he reduced 23 out of 28 or 82% of intussusceptions of less than 24 hours duration in infants older than six months Hiller in Australia reporting from the Royal Children s Hospital in Melbourne has been employing the barium enema in early cases of intussusception and in 41 such intussusceptions out of a total of 60 succeeded in reducing 24 all of the rest of them having been at least partly reduced Giordany Bass and Grier of Pittsburgh treated 27 cases of intussusception by barium enema and reduced 22 or 81% They had one death in spite of complete reduction with viable bowel in a child who had convulsions and died with aspiration pneumonia which may have been due to aspiration of the barium in the fluoroscopic room

What are the reasons for the resistance among surgeons to a form of treatment which in so many hands has given results superior to those achieved by primary operation? The objections commonly raised are these —

1 The original diagnosis may be uncertain
2 It is difficult to be sure of reduction
3 Will not the recurrence rate be higher?
4 Polyps and other tumors cause many intussusceptions and will not be found
5 In the unsuccessful cases a dangerous delay will have been caused
6 The bowel may rupture
7 Non viable bowel may be reduced

To answer these objections

1 To be sure in most forms of non-operative treatment of acute abdominal conditions as in acute cholecystitis acute pancreatitis perforated duodenal ulcer the first problem is that of diagnosis and the fact that in such conditions this cannot be made with absolute accuracy is an automatic disadvantage However in intussusception the diagnosis by fluoroscopy is fairly simple the criteria are characteristic and expertness in their recognition is soon acquired The inexperienced may reduce an intussusception without recognizing it certainly but no one can fail to diagnose an intussusception in the large intestine which does not reduce Intussusceptions still in the ileum cannot usually be demonstrated However they present as cases of mechanical intestinal obstruction and if enema does not disclose an intussusception the history the course and the fluoroscopic finding of distended loops will require operation Furthermore whereas most cases of intussusception are diagnosed clinically a few actually require barium enema for definitive diagnosis In many clinics in which the barium enema is not used therapeutically a good many intussusceptions have been inadvertently reduced in the course of what was meant to be a purely diagnostic barium enema Furthermore human nature being what it is pediatricians are much more likely to make a tentative diagnosis of intussusception before they are absolutely certain when this involves merely an enema rather than an operation As a pedagogic point we perform a barium enema whenever the question of intussusception is raised however confident we may be in a given instance that the suggestion is baseless The result we believe is substantially earlier definitive treatment

2 Accuracy of diagnosis of complete reduction is high We have made an erroneous diagnosis of complete reduction twice in the 77 cases The second of these was nine years ago Once we adopted it as iron clad policy that operation would be performed in every case in which there was not free filling of many loops of small bowel we have had no fear of mistaken diagnosis of complete reduction On the other hand as indicated in a previous section we have in five instances been unsure that reduction was complete only to discover at operation that it was

Even if we were to insist on operative confirmation of every enema reduction the procedure would still be safer and easier than operative reduction alone The use of hydrostatic pressure is safer quicker and less traumatic in the reduction of intussusception than is the manual

squeezing pulling and hauling of operative reduction

3 As to the rate of recurrence we have had only three in the 77 cases This rate of recurrence is about that which is reported from series of primary operative reductions

4 As concerns the possibility of failing to discover such a tumor by barium enema alone the incidence of specific causative lesions in our series has been only 13 in 199 cases of intussusception a total incidence of 6% These occurred practically all in the children over two years of age Furthermore the tumors which cause intussusception are rarely dangerous of themselves Meckel s diverticula occur in perhaps 1% of the *population and in addition it* would appear from our experience that intussusceptions caused by Meckel s diverticula are not usually completely reducible and will come to operation Polyps in children may be the cause of repeated intussusceptions or may cause anemia from bleeding but are not dangerous if not found at once Large lymphoid patches will usually cause no further trouble and such rare lesions as the occasional small enteric cyst or focus of ectopic pancreatic tissue are of little consequence except as they cause intussusception

5 As for the delay which might be caused by an unsuccessful attempt at reduction by enema it usually requires less than half an hour from *start to finish to reduce* an intussusception by this means It is our practice to call the operating room as soon as the diagnosis is made and we have usually finished the reduction in time to cancel the operation before preparations in the operating room have been completed This time in any case is employed for lavage of the stomach administration of intravenous fluids and antibiotics and so long as the procedure is under the control of the surgeon from the outset no time will be lost

6 *Rupture of the bowel can occur* with hydrostatic pressure as well as with manual reduction during operation However it is much less likely to occur with enema since less force is employed and that force is diffusely distributed We employ three feet to three feet six inches hydrostatic pressure and *religiously* abstain from manipulation of the bowel There have been a few instances in Scandinavia of *rupture from* manual reduction through the intact abdominal wall with or without enema

7 As for reducing non viable bowel it would appear that with a pressure of three feet six inches one cannot reduce gangrenous bowel Irreducibility of an intussusception as indicated by our experiments and the previous statements of others is determined by adhesions between the sheaths and by the degree of edema Both factors increase with time and become more *effective in* preventing reduction as the damage to bowel increases By the time the constriction *is so severe as to have produced gangrene* the moderate pressure employed will not reduce the bowel and it is important to note that the stress of this pressure is borne by the outer sheath the intussuscipiens which usually remains viable to the end

An advantage of the barium enema reduction so obvious as scarcely to need mention lies in the fact that 70% or more of the children will have escaped an anesthetic and a laparotomy with whatever risks are taken to attend these Furthermore although we insist that *even when* reduction is obviously complete all children *should be hospitalized and placed on* antibiotic therapy of the enteric poorly absorbable type to decrease the likelihood of a specific enteritis occurring in the injured bowel these periods of hospitalization are appreciably shorter than in patients who are operated upon The average duration of stay in the hospital for our last 45 patients treated primarily by barium enema was little more than four and a half days with many *of the children leaving the hospital in two or* three days

It is as well to re-emphasize again the fact that this method is not a substitute for operation nor an escape from operation It is as much a surgical procedure as is reduction of a fracture by traction The surgeon should be as ready to perform a laparotomy if it proves necessary as the orthopedist is to perform an open reduction *The treatment should be carried out*

by a surgeon and in a hospital It is not an office procedure nor a kitchen table remedy

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